

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

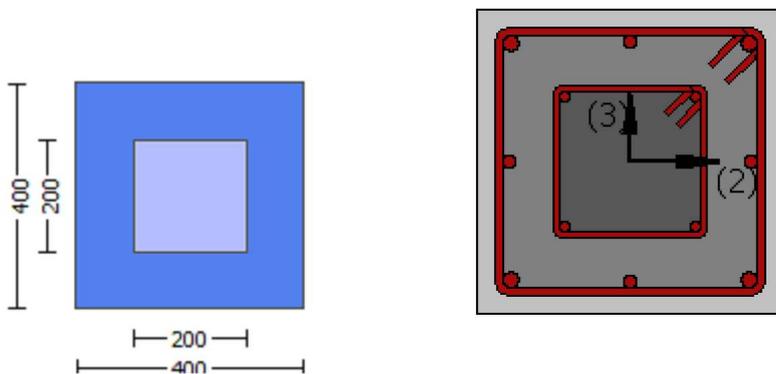
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column 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 Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

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

Jacket

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

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

Existing Column

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

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

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External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3619E+007$

Shear Force, $V_a = -4538.411$

EDGE -B-

Bending Moment, $M_b = -0.00349254$

Shear Force, $V_b = 4538.411$

BOTH EDGES

Axial Force, $F = -5974.992$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 1137.257$

-Compression: $A_{sc} = 1539.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sc, com} = 1137.257$

-Middle: $A_{st, mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $D_{bL, ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 327967.238$

V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 327967.238$

$V_{CoI} = 327967.238$

$k_n = 1.00$

displacement_ductility_demand = 0.01791406

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

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 22.75$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$
 $\mu = 1.3619E+007$
 $V_u = 4538.411$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5974.992$
 $A_g = 160000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$
 where:
 $V_{s1} = 251327.412$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 405571.497$
 $b_w = 400.00$

 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 $\theta_c = 0.00022652$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01264465$ ((4.29), Biskinis Phd)
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.89
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.7040E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 29.75$
 $N = 5974.992$
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 5.6801E+013$

 Calculation of Yielding Moment M_y

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

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0313993E-005$
 with $f_y = 529.9948$
 $d = 357.00$
 $y = 0.28030823$
 $A = 0.0188229$
 $B = 0.01057976$
 with $pt = 0.00796398$
 $pc = 0.00796398$
 $pv = 0.00281599$
 $N = 5974.992$
 $b = 400.00$
 $\rho = 0.12044818$
 $y_{comp} = 2.2027040E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.27977394$

A = 0.01864886
B = 0.01050082
with Es = 200000.00

Calculation of ratio l_b/d

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

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

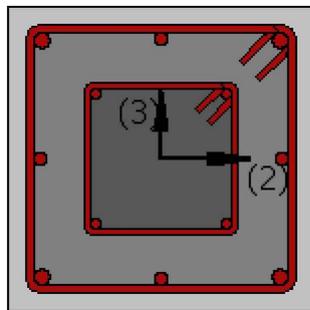
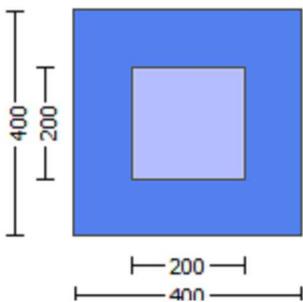
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

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

Jacket

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

Existing Column

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.8733604E-032$

EDGE -B-

Shear Force, $V_b = -3.8733604E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com} = 1137.257$

-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.48493697$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$

with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 3.3051E+008$

$M_{u1+} = 3.3051E+008$, 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

$M_{u1-} = 3.3051E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 3.3051E+008$

$M_{u2+} = 3.3051E+008$, 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

$M_{u2-} = 3.3051E+008$, 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:

$$u = 0.00010695$$
$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$
$$d = 357.00$$
$$d' = 43.00$$
$$v = 0.00126831$$
$$N = 5976.808$$
$$f_c = 33.00$$
$$c_o(5A.5, \text{TBDY}) = 0.002$$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538$
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00944538$

ω_e (5.4c) = 0.02209223

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i21} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i22} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$h_1 = 400.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

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

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

$h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$h_1 = 400.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

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

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

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $\phi_c = 0.00234957$

c = confinement factor = 1.03496

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 788.2136$

$fy_1 = 656.8447$

$su_1 = 0.032$

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

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

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

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

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

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

with $fs1 = (fs_jacket \cdot Asl,ten,jacket + fs_core \cdot Asl,ten,core) / Asl,ten = 656.8447$

with $Es1 = (Es_jacket \cdot Asl,ten,jacket + Es_core \cdot Asl,ten,core) / Asl,ten = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 788.2136$

$fy2 = 656.8447$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$

and also multiplied by the $shear_factor$ according to 15.7.1.4, with

$Shear_factor = 1.00$

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

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

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

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

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

with $fs2 = (fs_jacket \cdot Asl,com,jacket + fs_core \cdot Asl,com,core) / Asl,com = 656.8447$

with $Es2 = (Es_jacket \cdot Asl,com,jacket + Es_core \cdot Asl,com,core) / Asl,com = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.3333$

$fyv = 694.4444$

$suv = 0.032$

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 $fsv = (fs_jacket \cdot Asl,mid,jacket + fs_mid \cdot Asl,mid,core) / Asl,mid = 694.4444$

with $Esv = (Es_jacket \cdot Asl,mid,jacket + Es_mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.15851815$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.15851815$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

$c =$ confinement factor = 1.03496

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.20360129$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.20360129$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

$Mu = MRc$ (4.14) = 3.3051E+008

$u = su$ (4.1) = 0.00010695

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 0.00010695$$

$$\text{Mu} = 3.3051\text{E}+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00944538$$

$$\mu_{cc} \text{ (5.4c)} = 0.02209223$$

$$\text{ase} \text{ ((5.4d), TBDY)} = (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.24250288$$

$$\text{ase}_1 = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_{x} * F_{ywe}, \text{psh}_{y} * F_{ywe}) = 3.00633$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 3.00633$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 3.00633$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

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

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/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:

$$\mu = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00944538$$

$$\mu_{ue} \text{ (5.4c)} = 0.02209223$$

$$\mu_{se} \text{ ((5.4d), TBDY)} = (\mu_{se1} * A_{ext} + \mu_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$\mu_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$\mu_{se2} = \text{Max}(\mu_{se1}, \mu_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$\mu_{sh, \min} * F_{ywe} = \text{Min}(\mu_{sh, x} * F_{ywe}, \mu_{sh, y} * F_{ywe}) = 3.00633$$

$$\mu_{sh, x} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 3.00633$$

$$\mu_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\mu_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$\mu_{sh, y} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 3.00633$$

$$\mu_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\mu_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

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:

$$u = 0.00010695$$

$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

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

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

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

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16187171$$

$$\begin{aligned} \mu &= M_{Rc} (4.14) = 3.3051E+008 \\ u &= s_u (4.1) = 0.00010695 \end{aligned}$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

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

$$V_{Col0} = 454364.743$$

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

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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu = 1.0401148E-011$$

$$u = 3.8733604E-032$$

$$d = 0.8 * h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279252.68$$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

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

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$$b_w = 400.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

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

$$V_{Col0} = 454364.743$$

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

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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu = 1.0401148E-011$$

$$u = 3.8733604E-032$$

$$d = 0.8 * h = 320.00$$

$$N_u = 5976.808$$

Ag = 160000.00
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$
 where:
 Vs1 = 279252.68 is calculated for jacket, with:
 d = 320.00
 Av = 157079.633
 fy = 555.5556
 s = 100.00
 Vs1 is multiplied by Col1 = 1.00
 s/d = 0.3125
 Vs2 = 0.00 is calculated for core, with:
 d = 160.00
 Av = 100530.965
 fy = 444.4444
 s = 250.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.5625
 Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
 bw = 400.00

 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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
 Existing Column
 Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$
 #####
 External Height, H = 400.00
 External Width, W = 400.00
 Internal Height, H = 200.00
 Internal Width, W = 200.00
 Cover Thickness, c = 25.00
 Mean Confinement Factor overall section = 1.03496
 Element Length, L = 3000.00
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -1.5450773E-031$
EDGE -B-
Shear Force, $V_b = 1.5450773E-031$
BOTH EDGES
Axial Force, $F = -5976.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{c,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.48493697$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3051E+008$
 $\mu_{u1+} = 3.3051E+008$, 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
 $\mu_{u1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.3051E+008$
 $\mu_{u2+} = 3.3051E+008$, 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
 $\mu_{u2-} = 3.3051E+008$, 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:
 $\mu_u = 0.00010695$
 $\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\text{co (5A.5, TBDY)} = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00944538$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00944538$
 μ_w (5.4c) = 0.02209223
 μ_{ase} ((5.4d), TBDY) = $(\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.24250288$
 $\mu_{ase1} = 0.24250288$
 $\mu_{bo_1} = 340.00$
 $\mu_{ho_1} = 340.00$
 $\mu_{bi2_1} = 462400.00$
 $\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.24250288$

bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

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

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

yv = 0.0025
shv = 0.008

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.4444$$

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.15851815$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.15851815$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.20360129$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.20360129$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/d

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

Calculation of $Mu1$ -

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

$$u = 0.00010695$$

$$Mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00944538$$

$$we (5.4c) = 0.02209223$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$$

$$ase1 = 0.24250288$$

$$bo_1 = 340.00$$

ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

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

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

lo/lou,min = lb/lb,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 = 656.8447

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

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

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

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

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

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

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

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

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

with $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $fy_v = 694.4444$
 $suv = 0.032$
 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
 $lo/lo_{min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15851815$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15851815$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.20360129$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.20360129$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611263$

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

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16187171$
 $Mu = MRc (4.14) = 3.3051E+008$
 $u = su (4.1) = 0.00010695$

 Calculation of ratio lb/ld

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

 Calculation of Mu_{2+}

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

$u = 0.00010695$
 $Mu = 3.3051E+008$

 with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $we (5.4c) = 0.02209223$

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

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

with $f_{s2} = (f_{sjacket} \cdot A_{s1,com,jacket} + f_{s,core} \cdot A_{s1,com,core})/A_{s1,com} = 656.8447$

with $E_{s2} = (E_{sjacket} \cdot A_{s1,com,jacket} + E_{s,core} \cdot A_{s1,com,core})/A_{s1,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$s_{uv} = 0.032$

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

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

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

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

with $f_{sv} = (f_{sjacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 694.4444$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15851815$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15851815$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.20360129$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.20360129$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$\mu_u (4.9) = 0.16187171$

$\mu_u = M_{Rc} (4.14) = 3.3051E+008$

$u = \mu_u (4.1) = 0.00010695$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2} -

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

$u = 0.00010695$

$\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(c_u, cc) = 0.00944538$

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

From (5.4b), TBDY: $c_u = 0.00944538$

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.24250288$

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = $\text{Max}(ase1, ase2) = 0.24250288$

bo_2 = 192.00

ho_2 = 192.00

bi2_2 = 147456.00

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.00633$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.00633$

ps1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir, 1} \cdot n_{s, 1} = 157.0796$

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

h1 = 400.00

ps2 (internal) = $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir, 2} \cdot n_{s, 2} = 100.531$

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

h2 = 200.00

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.00633$

ps1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir, 1} \cdot n_{s, 1} = 157.0796$

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

h1 = 400.00

ps2 (internal) = $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir, 2} \cdot n_{s, 2} = 100.531$

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

h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: $c_c = 0.00234957$

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

with $fs1 = (fs_{\text{jacket}} \cdot A_{s1, \text{ten, jacket}} + fs_{\text{core}} \cdot A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 656.8447$

with $Es1 = (Es_{\text{jacket}} \cdot A_{s1, \text{ten, jacket}} + Es_{\text{core}} \cdot A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

$$su_2 = 0.4 * esu_2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_2_nominal = 0.08$,

For calculation of $esu_2_nominal$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

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

$$\text{with } fs_2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 656.8447$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

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

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

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

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

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

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 694.4444$$

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

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.15851815$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.15851815$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.20360129$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.20360129$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

'satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16187171$$

$$\mu_u = MR_c (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

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

$$V_{Col0} = 454364.743$$

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

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

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

Mean concrete strength: $fc' = (fc'_jacket * Area_jacket + fc'_core * Area_core) / Area_section = 29.75$, but $fc'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.4805782E-012$$

$$\nu_u = 1.5450773E-031$$

$$d = 0.8 \cdot h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279252.68$$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 463788.751$$

$$b_w = 400.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

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

$$V_{Col0} = 454364.743$$

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

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).

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

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75, \text{ but } f_c'^{0.5} \leq 8.3$$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.4805782E-012$$

$$\nu_u = 1.5450773E-031$$

$$d = 0.8 \cdot h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279252.68$$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 463788.751$$

$$b_w = 400.00$$

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -4.9633146E-011$

Shear Force, $V_2 = -4538.411$

Shear Force, $V_3 = 2.4658913E-014$

Axial Force, $F = -5974.992$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 1539.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com} = 1137.257$

-Middle: $A_{sl,mid} = 402.1239$

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: $A_{sl,ten,core} = 307.8761$

-Compression: $A_{sl,com,core} = 307.8761$

-Middle: $A_{sl,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = \phi_u = 0.01072102$

$$u = y + p = 0.01072102$$

- Calculation of y -

$$y = (M_y * L_s / 3) / E_{\text{eff}} = 0.00632045 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 2.1541E+008$$

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

$$\text{From table 10.5, ASCE 41_17: } E_{\text{eff}} = \text{factor} * E_c * I_g = 1.7040E+013$$

$$\text{factor} = 0.30$$

$$A_g = 160000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 29.75$$

$$N = 5974.992$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 5.6801E+013$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

$$y_{\text{ten}} = 1.0313993E-005$$

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

$$d = 357.00$$

$$y = 0.28030823$$

$$A = 0.0188229$$

$$B = 0.01057976$$

$$\text{with } p_t = 0.00442965$$

$$p_c = 0.00796398$$

$$p_v = 0.00281599$$

$$N = 5974.992$$

$$b = 400.00$$

$$" = 0.12044818$$

$$y_{\text{comp}} = 2.2027040E-005$$

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

$$E_c = 26999.444$$

$$y = 0.27977394$$

$$A = 0.01864886$$

$$B = 0.01050082$$

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

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.00440057$

with:

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

$$\text{shear control ratio } V_y E / V_{\text{col}} E = 0.48493697$$

$$d = d_{\text{external}} = 357.00$$

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

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00392699$$

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

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00050265$$

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

$$h_2 = 200.00$$

$$s_2 = 250.00$$

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

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

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

For the normalisation f_s of jacket is used.

$$N_{UD} = 5974.992$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 29.75$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 529.9948$$

$$f_{yTE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 542.9472$$

$$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.01874396$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 29.75$$

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

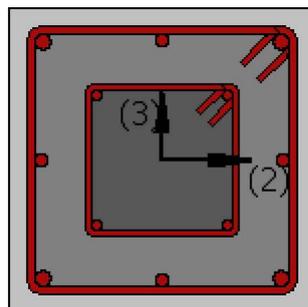
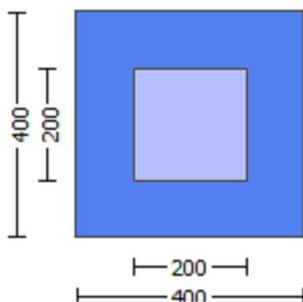
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column 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 Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of 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, $f_s = f_{sm} = 555.5556$
Existing Column
Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

External Height, $H = 400.00$
External Width, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d >= 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -4.9633146E-011$
Shear Force, $V_a = 2.4658913E-014$
EDGE -B-
Bending Moment, $M_b = -2.4306753E-011$
Shear Force, $V_b = -2.4658913E-014$
BOTH EDGES
Axial Force, $F = -5974.992$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 1137.257$
-Compression: $A_{sc} = 1539.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1137.257$
-Compression: $A_{sl,com} = 1137.257$
-Middle: $A_{sl,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = *V_n = 404607.064$
 V_n ((10.3), ASCE 41-17) = $knI*V_{CoIO} = 404607.064$
 $V_{CoI} = 404607.064$
 $knI = 1.00$
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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 22.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.9633146E-011$

$V_u = 2.4658913E-014$

$d = 0.8 \cdot h = 320.00$

$N_u = 5974.992$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$

where:

$V_{s1} = 251327.412$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440: $V_s + V_f \leq 405571.497$

$b_w = 400.00$

displacement ductility demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 2.0490289E-021$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00632045$ ((4.29), Biskinis Phd)

$M_y = 2.1541E+008$

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

From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 1.7040E+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$

$N = 5974.992$

$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 5.6801E+013$

Calculation of Yielding Moment M_y

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

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

$y_{\text{ten}} = 1.0313993E-005$

with $f_y = 529.9948$

$d = 357.00$

$y = 0.28030823$

$A = 0.0188229$

$B = 0.01057976$

with $pt = 0.00796398$

$pc = 0.00796398$

$pv = 0.00281599$

$N = 5974.992$

b = 400.00
" = 0.12044818
y_comp = 2.2027040E-005
with fc = 33.00
Ec = 26999.444
y = 0.27977394
A = 0.01864886
B = 0.01050082
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

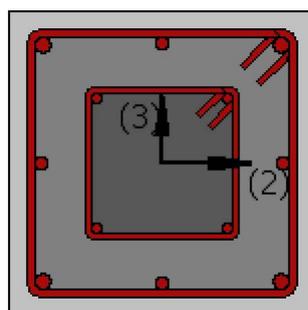
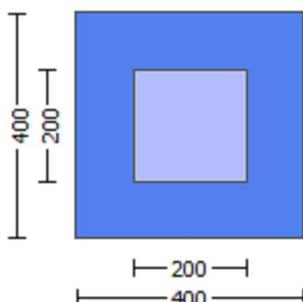
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (3)



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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.8733604E-032$

EDGE -B-

Shear Force, $V_b = -3.8733604E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com} = 1137.257$

-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3051E+008$

$M_{u1+} = 3.3051E+008$, 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

$M_{u1-} = 3.3051E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3051E+008$

$M_{u2+} = 3.3051E+008$, 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₋ = 3.3051E+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:

$$\phi_u = 0.00010695$$

$$M_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00944538$$

$$\phi_{ue} \text{ (5.4c)} = 0.02209223$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$\phi_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 3.00633$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.00633$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.00633$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

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:

$$u = 0.00010695$$

$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

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

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

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

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16187171$$

$$\begin{aligned} \text{Mu} &= \text{MRc} (4.14) = 3.3051\text{E}+008 \\ u &= \text{su} (4.1) = 0.00010695 \end{aligned}$$

Calculation of ratio l_b/l_d

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

Calculation of Mu_{2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00010695$
 $\text{Mu} = 3.3051\text{E}+008$

with full section properties:

$$\begin{aligned} b &= 400.00 \\ d &= 357.00 \\ d' &= 43.00 \\ v &= 0.00126831 \\ N &= 5976.808 \\ f_c &= 33.00 \\ c_o (5A.5, \text{TB DY}) &= 0.002 \\ \text{Final value of } \phi_u: \phi_u^* &= \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538 \\ \text{The Shear_factor is considered equal to 1 (pure moment strength)} \\ \text{From (5.4b), TB DY: } \phi_u &= 0.00944538 \\ \phi_{we} (5.4c) &= 0.02209223 \\ \phi_{ase} ((5.4d), \text{TB DY}) &= (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.24250288 \\ \phi_{ase1} &= 0.24250288 \\ \phi_{bo_1} &= 340.00 \\ \phi_{ho_1} &= 340.00 \\ \phi_{bi2_1} &= 462400.00 \\ \phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) &= 0.24250288 \\ \phi_{bo_2} &= 192.00 \\ \phi_{ho_2} &= 192.00 \\ \phi_{bi2_2} &= 147456.00 \\ \phi_{psh, \min} * \phi_{fywe} &= \text{Min}(\phi_{psh, x} * \phi_{fywe}, \phi_{psh, y} * \phi_{fywe}) = 3.00633 \end{aligned}$$

$$\begin{aligned} \phi_{psh, x} * \phi_{fywe} &= \phi_{psh1} * \phi_{fywe1} + \phi_{ps2} * \phi_{fywe2} = 3.00633 \\ \phi_{ps1} (\text{external}) &= (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699 \\ A_{sh1} &= A_{stir_1} * n_{s_1} = 157.0796 \\ \text{No stirups, } n_{s_1} &= 2.00 \\ h_1 &= 400.00 \\ \phi_{ps2} (\text{internal}) &= (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265 \\ A_{sh2} &= A_{stir_2} * n_{s_2} = 100.531 \\ \text{No stirups, } n_{s_2} &= 2.00 \\ h_2 &= 200.00 \end{aligned}$$

$$\begin{aligned} \phi_{psh, y} * \phi_{fywe} &= \phi_{psh1} * \phi_{fywe1} + \phi_{ps2} * \phi_{fywe2} = 3.00633 \\ \phi_{ps1} (\text{external}) &= (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699 \\ A_{sh1} &= A_{stir_1} * n_{s_1} = 157.0796 \\ \text{No stirups, } n_{s_1} &= 2.00 \\ h_1 &= 400.00 \\ \phi_{ps2} (\text{internal}) &= (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265 \\ A_{sh2} &= A_{stir_2} * n_{s_2} = 100.531 \\ \text{No stirups, } n_{s_2} &= 2.00 \\ h_2 &= 200.00 \end{aligned}$$

$$\begin{aligned} A_{sec} &= 160000.00 \\ s_1 &= 100.00 \\ s_2 &= 250.00 \\ \phi_{fywe1} &= 694.4444 \\ \phi_{fywe2} &= 555.5556 \\ \phi_{fce} &= 33.00 \end{aligned}$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$
 $c = \text{confinement factor} = 1.03496$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

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

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

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

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

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

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

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

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 788.2136$

$fy2 = 656.8447$

$su2 = 0.032$

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

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

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

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

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

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

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

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

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.3333$

$fyv = 694.4444$

$suv = 0.032$

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 $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 694.4444$

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

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15851815$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15851815$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.20360129$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.20360129$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_s, y_2$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.16187171$$

$$\mu_u = M_{Rc}(4.14) = 3.3051E+008$$

$$u = s_u(4.1) = 0.00010695$$

Calculation of ratio l_b/d

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

Calculation of μ_u -

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

$$u = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e(5.4c) = 0.02209223$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

 $A_{sec} = 160000.00$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 656.8447$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 788.2136$$

$$fy_2 = 656.8447$$

$$su_2 = 0.032$$

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

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

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

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.

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs_{\text{jacket}} * Asl, \text{mid, jacket} + fs_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.4444$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.15851815$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.15851815$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 34.15357$$

$$cc (5A.5, \text{TBDY}) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.20360129$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.20360129$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.07611263$$

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

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

--->
 s_u (4.9) = 0.16187171
 $M_u = MR_c$ (4.14) = 3.3051E+008
 $u = s_u$ (4.1) = 0.00010695

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$
 $V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$
 $V_{Col0} = 454364.743$
 $k_{nl} = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$
 $M_u = 1.0401148E-011$
 $V_u = 3.8733604E-032$
 $d = 0.8 * h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:
 $V_{s1} = 279252.68$ is calculated for jacket, with:

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

V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$

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

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$

V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
 $b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$
 $V_{Col0} = 454364.743$
 $k_{nl} = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1.0401148E-011$$

$$V_u = 3.8733604E-032$$

$$d = 0.8 \cdot h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279252.68$$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

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

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$$b_w = 400.00$$

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -1.5450773E-031$
EDGE -B-
Shear Force, $V_b = 1.5450773E-031$
BOTH EDGES
Axial Force, $F = -5976.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1137.257$
-Compression: $A_{sl,com} = 1137.257$
-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3051E+008$
 $\mu_{u1+} = 3.3051E+008$, 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
 $\mu_{u1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.3051E+008$
 $\mu_{u2+} = 3.3051E+008$, 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
 $\mu_{u2-} = 3.3051E+008$, 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:
 $\mu_u = 0.00010695$
 $\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\omega (5A.5, \text{TBDY}) = 0.002$
Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00944538$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_{cu} = 0.00944538$
we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

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

with $f_{s2} = (f_{sjacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 656.8447$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$s_{uv} = 0.032$

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

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

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

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

with $f_{sv} = (f_{sjacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 694.4444$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15851815$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15851815$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.20360129$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.20360129$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u (4.9) = 0.16187171$

$\mu_u = M_{Rc} (4.14) = 3.3051E+008$

$u = s_u (4.1) = 0.00010695$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u1} -

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

$u = 0.00010695$

$\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(c_u, cc) = 0.00944538$

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

From (5.4b), TBDY: $c_u = 0.00944538$

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.24250288$

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = $\text{Max}(ase1, ase2) = 0.24250288$

bo_2 = 192.00

ho_2 = 192.00

bi2_2 = 147456.00

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.00633$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.00633$

ps1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir, 1} \cdot n_{s, 1} = 157.0796$

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

h1 = 400.00

ps2 (internal) = $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir, 2} \cdot n_{s, 2} = 100.531$

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

h2 = 200.00

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.00633$

ps1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir, 1} \cdot n_{s, 1} = 157.0796$

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

h1 = 400.00

ps2 (internal) = $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir, 2} \cdot n_{s, 2} = 100.531$

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

h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: $c_c = 0.00234957$

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with $fs1 = (fs_{jacket} \cdot A_{s1, ten, jacket} + fs_{core} \cdot A_{s1, ten, core}) / A_{s1, ten} = 656.8447$

with $Es1 = (Es_{jacket} \cdot A_{s1, ten, jacket} + Es_{core} \cdot A_{s1, ten, core}) / A_{s1, ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

For calculation of $esu_{2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.

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

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_v = (fs_{jacket} * Asl_{,mid,jacket} + fs_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 694.4444$$

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

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.15851815$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.15851815$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.20360129$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.20360129$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/ld

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

Calculation of Mu_{2+}

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

$$u = 0.00010695$$

$$Mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00944538$

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

From (5.4b), TBDY: $cu = 0.00944538$

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = $\text{Max}(ase1, ase2) = 0.24250288$

bo_2 = 192.00

ho_2 = 192.00

bi2_2 = 147456.00

$psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 3.00633$

$psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 3.00633$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir_1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 400.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir_2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 200.00

$psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 3.00633$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir_1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 400.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir_2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 0.00010695

Mu = 3.3051E+008

with full section properties:

b = 400.00

d = 357.00

$d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $w_e (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 3.00633$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $f_{ywe1} = 694.4444$
 $f_{ywe2} = 555.5556$
 $f_c = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$
 $c = confinement\ factor = 1.03496$

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

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

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

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

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

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

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

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

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

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 788.2136$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 454364.743

Calculation of Shear Strength at edge 1, Vr1 = 454364.743

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO$$

$$VColO = 454364.743$$

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

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.4805782E-012$

$\nu_u = 1.5450773E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 454364.743$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.4805782E-012$

$\nu_u = 1.5450773E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
 $bw = 400.00$

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 400.00$
External Width, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d >= 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.3619E+007$
Shear Force, $V_2 = -4538.411$
Shear Force, $V_3 = 2.4658913E-014$
Axial Force, $F = -5974.992$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1137.257$
-Compression: $As_c = 1539.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{mid} = 402.1239$
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: $As_{t,ten,core} = 307.8761$
-Compression: $As_{c,com,core} = 307.8761$
-Middle: $As_{mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = u = 0.01704522$
 $u = y + p = 0.01704522$

- Calculation of y -

$y = (My * Ls / 3) / E_{eff} = 0.01264465$ ((4.29), Biskinis Phd))

$My = 2.1541E+008$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 3000.89

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$

factor = 0.30

$Ag = 160000.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 29.75$

$N = 5974.992$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.6801E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

$y_{ten} = 1.0313993E-005$

with $f_y = 529.9948$

$d = 357.00$

$y = 0.28030823$

$A = 0.0188229$

$B = 0.01057976$

with $pt = 0.00442965$

$pc = 0.00796398$

$pv = 0.00281599$

$N = 5974.992$

$b = 400.00$

" = 0.12044818

$y_{comp} = 2.2027040E-005$

with $fc = 33.00$

$E_c = 26999.444$

$y = 0.27977394$

$A = 0.01864886$

$B = 0.01050082$

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: $p = 0.00440057$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.48493697$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00442965$

jacket: $s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00392699$

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

$h_1 = 400.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$

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

$h_2 = 200.00$

$s_2 = 250.00$

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.

$N_{UD} = 5974.992$

$A_g = 160000.00$

$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 29.75$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 529.9948$

$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 542.9472$

$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.01874396$

$b = 400.00$

$d = 357.00$

$f_{cE} = 29.75$

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

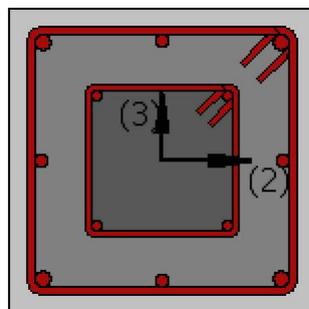
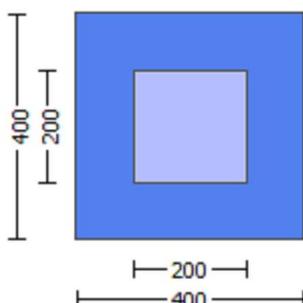
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column 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 Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

#####

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

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3619E+007$

Shear Force, $V_a = -4538.411$

EDGE -B-

Bending Moment, $M_b = -0.00349254$

Shear Force, $V_b = 4538.411$

BOTH EDGES

Axial Force, $F = -5974.992$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $As_{l,com} = 1137.257$

-Middle: $As_{l,mid} = 402.1239$

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

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 404607.064$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 404607.064$
 $V_{CoI} = 404607.064$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.09482936$

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

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 22.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 0.00349254$
 $V_u = 4538.411$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5974.992$
 $A_g = 160000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$
where:
 $V_{s1} = 251327.412$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 405571.497$
 $bw = 400.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 0.00011987$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00126409$ ((4.29), Biskinis Phd))
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.7040E+013$
 $factor = 0.30$
 $A_g = 160000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 29.75$
 $N = 5974.992$
 $E_c \cdot I_g = E_c \cdot I_{g_jacket} + E_c \cdot I_{g_core} = 5.6801E+013$

Calculation of Yielding Moment M_y

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

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0313993E-005$
with $f_y = 529.9948$
 $d = 357.00$
 $y = 0.28030823$

$A = 0.0188229$
 $B = 0.01057976$
 with $pt = 0.00796398$
 $pc = 0.00796398$
 $pv = 0.00281599$
 $N = 5974.992$
 $b = 400.00$
 $" = 0.12044818$
 $y_comp = 2.2027040E-005$
 with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.27977394$
 $A = 0.01864886$
 $B = 0.01050082$
 with $Es = 200000.00$

Calculation of ratio lb/d

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

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

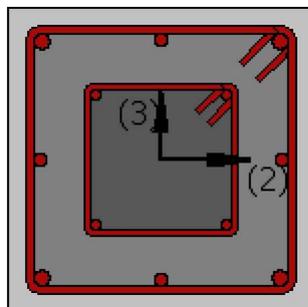
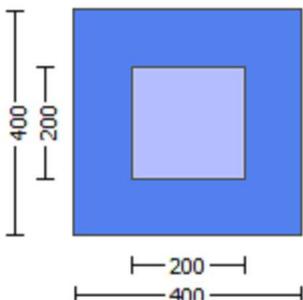
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.8733604E-032$

EDGE -B-

Shear Force, $V_b = -3.8733604E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl, \text{com}} = 1137.257$

-Middle: $A_{sl, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3051E+008$

$M_{u1+} = 3.3051E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction

which is defined for the static loading combination

$Mu1- = 3.3051E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr2 = \text{Max}(Mu2+, Mu2-) = 3.3051E+008$

$Mu2+ = 3.3051E+008$, 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

$Mu2- = 3.3051E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of $Mu1+$

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

$u = 0.00010695$

$Mu = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

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

Final value of α_{cu} : $\alpha_{cu}^* = \text{shear_factor} * \text{Max}(\alpha_{cu}, \alpha_{cc}) = 0.00944538$

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

From (5.4b), TBDY: $\alpha_{cu} = 0.00944538$

we (5.4c) = 0.02209223

$\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.24250288$

$\alpha_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i21} = 462400.00$

$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i22} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

$ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * n_{s1} = 157.0796$

No stirups, $n_{s1} = 2.00$

$h1 = 400.00$

$ps2$ (internal) = $(A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * n_{s2} = 100.531$

No stirups, $n_{s2} = 2.00$

$h2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

$ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * n_{s1} = 157.0796$

No stirups, $n_{s1} = 2.00$

$h1 = 400.00$

$ps2$ (internal) = $(A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * n_{s2} = 100.531$

No stirups, $n_{s2} = 2.00$

$h2 = 200.00$

$A_{sec} = 160000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$
 $c = \text{confinement factor} = 1.03496$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

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

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

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

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

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

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

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

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 788.2136$

$fy2 = 656.8447$

$su2 = 0.032$

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

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

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

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

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

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

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

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

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.3333$

$fyv = 694.4444$

$suv = 0.032$

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 $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 694.4444$

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

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15851815$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15851815$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.20360129$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.20360129$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_s, y_2$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.16187171$$

$$\mu_u = M_{Rc}(4.14) = 3.3051E+008$$

$$u = s_u(4.1) = 0.00010695$$

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:

$$u = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e(5.4c) = 0.02209223$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o1} = 340.00$$

$$h_{o1} = 340.00$$

$$b_{i21} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o2} = 192.00$$

$$h_{o2} = 192.00$$

$$b_{i22} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

 $A_{sec} = 160000.00$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 656.8447$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 788.2136$$

$$fy_2 = 656.8447$$

$$su_2 = 0.032$$

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

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

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

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.

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs_{\text{jacket}} * Asl, \text{mid, jacket} + fs_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.4444$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.15851815$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.15851815$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 34.15357$$

$$cc (5A.5, \text{TBDY}) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.20360129$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.20360129$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.07611263$$

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

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

--->
su (4.9) = 0.16187171
Mu = MRc (4.14) = 3.3051E+008
u = su (4.1) = 0.00010695

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 = 0.00010695
Mu = 3.3051E+008

with full section properties:

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00944538
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00944538
we (5.4c) = 0.02209223
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.4444$
 $f_{ywe2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 788.2136$
 $fy_1 = 656.8447$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1_nominal = 0.08$,
 For calculation of $esu_1_nominal$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_jacket * A_{sl, ten, jacket} + fs_core * A_{sl, ten, core}) / A_{sl, ten} = 656.8447$
 with $Es_1 = (Es_jacket * A_{sl, ten, jacket} + Es_core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 788.2136$
 $fy_2 = 656.8447$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su_2 = 0.4 * esu_2_nominal ((5.5), TBDY) = 0.032$
 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 $fs_2 = (fs_jacket * A_{sl, com, jacket} + fs_core * A_{sl, com, core}) / A_{sl, com} = 656.8447$
 with $Es_2 = (Es_jacket * A_{sl, com, jacket} + Es_core * A_{sl, com, core}) / A_{sl, com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $fy_v = 694.4444$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_jacket * A_{sl, mid, jacket} + fs_mid * A_{sl, mid, core}) / A_{sl, mid} = 694.4444$
 with $Es_v = (Es_jacket * A_{sl, mid, jacket} + Es_mid * A_{sl, mid, core}) / A_{sl, mid} = 200000.00$
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.15851815$
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.15851815$
 $v = A_{sl, mid} / (b * d) * (fsv / f_c) = 0.05925912$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.20360129$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.20360129$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611263$$

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

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

$$\text{su (4.9)} = 0.16187171$$

$$\text{Mu} = \text{MRc (4.14)} = 3.3051\text{E}+008$$

$$u = \text{su (4.1)} = 0.00010695$$

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

$$u = 0.00010695$$

$$\text{Mu} = 3.3051\text{E}+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh,min}*F_{ywe} = \text{Min}(p_{sh,x}*F_{ywe}, p_{sh,y}*F_{ywe}) = 3.00633$$

$$p_{sh,x}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1}*h_1/s_1)/A_{sec} = 0.00392699$$

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

No stirups, n_s₁ = 2.00

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2}*h_2/s_2)/A_{sec} = 0.00050265$$

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

No stirups, n_s₂ = 2.00

$$h_2 = 200.00$$

$$p_{sh,y}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1}*h_1/s_1)/A_{sec} = 0.00392699$$

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

No stirups, n_s₁ = 2.00

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2}*h_2/s_2)/A_{sec} = 0.00050265$$

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

No stirrups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357
cc (5A.5, TBDY) = 0.00234957
c = confinement factor = 1.03496
1 = $Asl,ten/(b*d)*(fs1/fc) = 0.20360129$
2 = $Asl,com/(b*d)*(fs2/fc) = 0.20360129$
v = $Asl,mid/(b*d)*(fsv/fc) = 0.07611263$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

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

---->
su (4.9) = 0.16187171
Mu = MRc (4.14) = 3.3051E+008
u = su (4.1) = 0.00010695

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 454364.743

Calculation of Shear Strength at edge 1, Vr1 = 454364.743

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 454364.743
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 = 29.75, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 1.0401148E-011
Vu = 3.8733604E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279252.68

where:
Vs1 = 279252.68 is calculated for jacket, with:

d = 320.00
Av = 157079.633
fy = 555.5556
s = 100.00

Vs1 is multiplied by Col1 = 1.00
s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00

Vs2 is multiplied by Col2 = 0.00
s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 463788.751
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 454364.743

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 454364.743
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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.0401148E-011

Vu = 3.8733604E-032

d = 0.8*h = 320.00

Nu = 5976.808

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279252.68

where:

Vs1 = 279252.68 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 463788.751

bw = 400.00

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03496
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou, \min} >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -1.5450773E-031$
EDGE -B-
Shear Force, $V_b = 1.5450773E-031$
BOTH EDGES
Axial Force, $F = -5976.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st, \text{ten}} = 1137.257$
-Compression: $A_{st, \text{com}} = 1137.257$
-Middle: $A_{st, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.48493697$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 3.3051E+008$
 $Mu_{1+} = 3.3051E+008$, 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
 $Mu_{1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 3.3051E+008$
 $Mu_{2+} = 3.3051E+008$, 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
 $Mu_{2-} = 3.3051E+008$, 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:
 $\phi_u = 0.00010695$
 $M_u = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_c = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

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

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

$$su_1 = 0.4 * es_{u1, \text{nominal}} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } es_{u1, \text{nominal}} = 0.08,$$

For calculation of $es_{u1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fs_{y1} = fs_1 / 1.2$, from table 5.1, TBDY.

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

$$\text{with } fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 656.8447$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 788.2136$$

$$fy_2 = 656.8447$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

u = 0.00010695

Mu = 3.3051E+008

with full section properties:

b = 400.00

d = 357.00

$d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $w_e (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 3.00633$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $f_{ywe1} = 694.4444$
 $f_{ywe2} = 555.5556$
 $f_c = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$
 $c = confinement\ factor = 1.03496$

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

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

$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,

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

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 656.8447$
 with $Es1 = (Es, jacket * A_{sl, ten, jacket} + Es, core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 788.2136$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

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:

$$u = 0.00010695$$

$$Mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e (5.4c) = 0.02209223$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

$$\text{No stirrups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

$$\text{No stirrups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

$$\text{No stirrups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

$$\text{No stirrups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

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

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

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

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

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.

$$\text{with } fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 656.8447$$

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

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

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

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

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

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

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

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

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

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

yv = 0.0025
shv = 0.008
ftv = 833.3333
fyv = 694.4444
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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 0.00010695
Mu = 3.3051E+008

with full section properties:

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00944538$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00944538$
we (5.4c) = 0.02209223
ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = $\text{Max}(ase1, ase2) = 0.24250288$
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
 $psh_{min} * Fywe = \text{Min}(psh_x * Fywe, psh_y * Fywe) = 3.00633$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.00633$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$
Ash1 = $A_{stir_1} * ns_1 = 157.0796$
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00050265$
Ash2 = $A_{stir_2} * ns_2 = 100.531$
No stirups, ns_2 = 2.00
h2 = 200.00

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.00633$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$
Ash1 = $A_{stir_1} * ns_1 = 157.0796$
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00050265$
Ash2 = $A_{stir_2} * ns_2 = 100.531$
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$
c = confinement factor = 1.03496

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
su1 = $0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,
For calculation of $esu1_{nominal}$ and y1, sh1, ft1, fy1, it is considered
characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

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

with $fs_1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 656.8447$

with $Es_1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 788.2136$

$fy_2 = 656.8447$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

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

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered

characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

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

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

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$su_v = 0.032$

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

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

$su_v = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

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

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

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

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

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

with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.4444$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15851815$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15851815$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.20360129$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.20360129$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.16187171$

$Mu = MRc (4.14) = 3.3051E+008$

$u = su (4.1) = 0.00010695$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

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

$V_{ColO} = 454364.743$

$kn1 = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 2.4805782E-012$

$\nu_u = 1.5450773E-031$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

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

$V_{ColO} = 454364.743$

$kn1 = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 2.4805782E-012$

$\nu_u = 1.5450773E-031$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

Av = 100530.965

fy = 444.4444

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 463788.751

bw = 400.00

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 Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

External Height, H = 400.00

External Width, W = 400.00

Internal Height, H = 200.00

Internal Width, W = 200.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lb/ld >= 1)

No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.4306753E-011

Shear Force, V2 = 4538.411

Shear Force, V3 = -2.4658913E-014

Axial Force, F = -5974.992

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 2676.637

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257

-Compression: Asl,com = 1137.257

-Middle: Asl,mid = 402.1239

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com,core} = 307.8761$

-Middle: $A_{sl,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = * u = 0.01072102$
 $u = y + p = 0.01072102$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00632045$ ((4.29), Biskinis Phd)

$M_y = 2.1541E+008$

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

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 29.75$

$N = 5974.992$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.6801E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

$y_{ten} = 1.0313993E-005$

with $f_y = 529.9948$

$d = 357.00$

$y = 0.28030823$

$A = 0.0188229$

$B = 0.01057976$

with $pt = 0.00442965$

$pc = 0.00796398$

$pv = 0.00281599$

$N = 5974.992$

$b = 400.00$

$" = 0.12044818$

$y_{comp} = 2.2027040E-005$

with $fc = 33.00$

$E_c = 26999.444$

$y = 0.27977394$

$A = 0.01864886$

$B = 0.01050082$

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: $p = 0.00440057$

with:

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

shear control ratio $V_y E / V_{col} E = 0.48493697$

$d = d_{external} = 357.00$

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

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$$

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

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$$

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

$$h_2 = 200.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 5974.992$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c_jacket} \cdot A_{\text{jacket}} + f_{c_core} \cdot A_{\text{core}}) / \text{section_area} = 29.75$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot A_{\text{ext_Long_Reinf}} + f_{y_int_Long_Reinf} \cdot A_{\text{int_Long_Reinf}}) / A_{\text{Tot_Long_Rein}} = 529.9948$$

$$f_{yIE} = (f_{y_ext_Trans_Reinf} \cdot A_{\text{ext_Trans_Reinf}} + f_{y_int_Trans_Reinf} \cdot A_{\text{int_Trans_Reinf}}) / A_{\text{Tot_Trans_Rein}} = 542.9472$$

$$p_l = A_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01874396$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 29.75$$

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

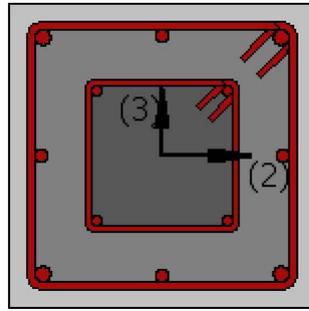
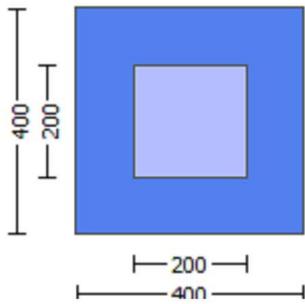
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column 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 Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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

Existing Column

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

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -4.9633146E-011$

Shear Force, $V_a = 2.4658913E-014$

EDGE -B-

Bending Moment, Mb = -2.4306753E-011

Shear Force, Vb = -2.4658913E-014

BOTH EDGES

Axial Force, F = -5974.992

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 2676.637

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257

-Compression: Asl,com = 1137.257

-Middle: Asl,mid = 402.1239

Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = *Vn = 404607.064

Vn ((10.3), ASCE 41-17) = knl*VColO = 404607.064

VCol = 404607.064

knl = 1.00

displacement_ductility_demand = 0.00

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 = 22.75, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.4306753E-011

Vu = 2.4658913E-014

d = 0.8*h = 320.00

Nu = 5974.992

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412

where:

Vs1 = 251327.412 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 500.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 400.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 405571.497

bw = 400.00

displacement_ductility_demand is calculated as / y

- Calculation of / y for END B -

for rotation axis 2 and integ. section (b)

From analysis, chord rotation = 4.0767216E-023

y = (My*Ls/3)/Eleff = 0.00632045 ((4.29),Biskinis Phd))

My = 2.1541E+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 = 1.7040E+013

factor = 0.30

Ag = 160000.00

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$

N = 5974.992

$E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 5.6801\text{E}+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

$y_{\text{ten}} = 1.0313993\text{E}-005$

with $f_y = 529.9948$

d = 357.00

$y = 0.28030823$

A = 0.0188229

B = 0.01057976

with $p_t = 0.00796398$

$p_c = 0.00796398$

$p_v = 0.00281599$

N = 5974.992

b = 400.00

" = 0.12044818

$y_{\text{comp}} = 2.2027040\text{E}-005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.27977394$

A = 0.01864886

B = 0.01050082

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

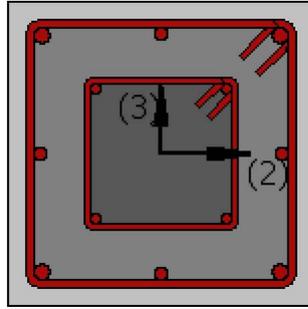
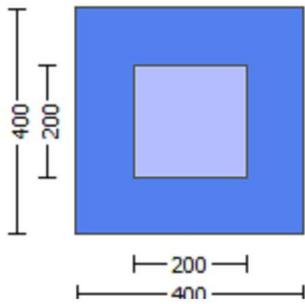
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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

Existing Column

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

#####

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

Jacket

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

Existing Column

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.8733604E-032$

EDGE -B-

Shear Force, $V_b = -3.8733604E-032$

BOTH EDGES

Axial Force, $F = -5976.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{,ten} = 1137.257$
-Compression: $As_{,com} = 1137.257$
-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3051E+008$
 $\mu_{u1+} = 3.3051E+008$, 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
 $\mu_{u1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.3051E+008$
 $\mu_{u2+} = 3.3051E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 3.3051E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

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

$\phi_u = 0.00010695$
 $\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\phi_{co} \text{ (5A.5, TBDY)} = 0.002$
Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00944538$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_{cu} = 0.00944538$
 $\phi_{we} \text{ (5.4c)} = 0.02209223$
 $\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.24250288$
 $\phi_{ase1} = 0.24250288$
 $\phi_{bo_1} = 340.00$
 $\phi_{ho_1} = 340.00$
 $\phi_{bi2_1} = 462400.00$
 $\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$
 $\phi_{bo_2} = 192.00$
 $\phi_{ho_2} = 192.00$
 $\phi_{bi2_2} = 147456.00$
 $\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 3.00633$

 $\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.00633$
 $\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
No stirups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
No stirups, $n_{s_2} = 2.00$

h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

with $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 694.4444$
 with $E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15851815$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.15851815$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05925912$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.20360129$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.20360129$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$\mu (4.9) = 0.16187171$
 $\mu = M_{Rc} (4.14) = 3.3051E+008$
 $u = \mu (4.1) = 0.00010695$

 Calculation of ratio l_b/d

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

 Calculation of μ_{u1} -

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

$u = 0.00010695$
 $\mu = 3.3051E+008$

 with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.00944538$
 $\mu_u (5.4c) = 0.02209223$
 $\mu_{ase} ((5.4d), TBDY) = (\mu_{ase1} \cdot A_{ext} + \mu_{ase2} \cdot A_{int}) / A_{sec} = 0.24250288$
 $\mu_{ase1} = 0.24250288$
 $\mu_{bo_1} = 340.00$
 $\mu_{ho_1} = 340.00$
 $\mu_{bi2_1} = 462400.00$
 $\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.24250288$
 $\mu_{bo_2} = 192.00$
 $\mu_{ho_2} = 192.00$
 $\mu_{bi2_2} = 147456.00$
 $\mu_{psh,min} \cdot F_{ywe} = \text{Min}(\mu_{psh,x} \cdot F_{ywe}, \mu_{psh,y} \cdot F_{ywe}) = 3.00633$

 $\mu_{psh,x} \cdot F_{ywe} = \mu_{psh1} \cdot F_{ywe1} + \mu_{psh2} \cdot F_{ywe2} = 3.00633$
 $\mu_{ps1} (\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 400.00$

$$ps_2 \text{ (internal)} = (Ash_2 * h_2 / s_2) / A_{sec} = 0.00050265$$

$$Ash_2 = Astir_2 * ns_2 = 100.531$$

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

$$h_2 = 200.00$$

$$psh_y * Fy_{we} = psh_1 * Fy_{we1} + ps_2 * Fy_{we2} = 3.00633$$

$$ps_1 \text{ (external)} = (Ash_1 * h_1 / s_1) / A_{sec} = 0.00392699$$

$$Ash_1 = Astir_1 * ns_1 = 157.0796$$

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

$$h_1 = 400.00$$

$$ps_2 \text{ (internal)} = (Ash_2 * h_2 / s_2) / A_{sec} = 0.00050265$$

$$Ash_2 = Astir_2 * ns_2 = 100.531$$

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

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

$$lo/lou, \text{min} = lb/ld = 1.00$$

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

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.

$$\text{with } fs_1 = (fs_{\text{jacket}} * A_{sl, \text{ten, jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 656.8447$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 788.2136$$

$$fy_2 = 656.8447$$

$$su_2 = 0.032$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 1.00$$

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

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.

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

$$lo/lou, \text{min} = lb/ld = 1.00$$

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

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

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$

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

$$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15851815$$

$$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.15851815$$

$$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} \text{ (5A.2, TBDY)} = 34.15357$$

$$c_c \text{ (5A.5, TBDY)} = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.20360129$$

$$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.20360129$$

$$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u \text{ (4.9)} = 0.16187171$$

$$\mu_u = M_{Rc} \text{ (4.14)} = 3.3051E+008$$

$$u = s_u \text{ (4.1)} = 0.00010695$$

Calculation of ratio lb/ld

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

Calculation of μ_{u2+}

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

$$u = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.00944538$$

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

From (5.4b), TBDY: $c_u = 0.00944538$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.00633$$

$$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$$

Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

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

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

yv = 0.0025
shv = 0.008
ftv = 833.3333
fyv = 694.4444
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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 694.4444$$

$$\text{with } Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.15851815$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.15851815$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.20360129$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.20360129$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

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:

$$u = 0.00010695$$

$$Mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$fc = 33.00$$

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

$$\text{Final value of } cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00944538$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00944538$$

$$we (5.4c) = 0.02209223$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.24250288$$

$$ase1 = 0.24250288$$

$$bo_1 = 340.00$$

$$ho_1 = 340.00$$

$$bi2_1 = 462400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.24250288$$

$$bo_2 = 192.00$$

$$ho_2 = 192.00$$

$$bi2_2 = 147456.00$$

$$psh_min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 3.00633$$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 454364.743

Calculation of Shear Strength at edge 1, Vr1 = 454364.743

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 454364.743

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 = 29.75, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.0401148E-011

Vu = 3.8733604E-032

d = 0.8*h = 320.00

Nu = 5976.808

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279252.68

where:

Vs1 = 279252.68 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs1 is multiplied by Col1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 463788.751
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 454364.743
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 454364.743
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 = 29.75, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0401148E-011
Vu = 3.8733604E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279252.68
where:
Vs1 = 279252.68 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 555.5556
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 463788.751
bw = 400.00

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} >= 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -1.5450773E-031$

EDGE -B-

Shear Force, $V_b = 1.5450773E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1137.257$

-Compression: $A_{sl,com} = 1137.257$

-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3051E+008$

$M_{u1+} = 3.3051E+008$, 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

$M_{u1-} = 3.3051E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3051E+008$

$M_{u2+} = 3.3051E+008$, 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₋ = 3.3051E+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:

$$\phi_u = 0.00010695$$

$$M_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00944538$$

$$\phi_{ue} \text{ (5.4c)} = 0.02209223$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$\phi_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 3.00633$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.00633$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.00633$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

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:

$$u = 0.00010695$$

$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16187171$$

$$\begin{aligned} \mu &= MRC(4.14) = 3.3051E+008 \\ u &= su(4.1) = 0.00010695 \end{aligned}$$

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:
 $u = 0.00010695$
 $\mu = 3.3051E+008$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.00944538$$

$$\mu_{cc} \text{ (5.4c)} = 0.02209223$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.24250288$$

$$\mu_{ase1} = 0.24250288$$

$$b_{o1} = 340.00$$

$$h_{o1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.24250288$$

$$b_{o2} = 192.00$$

$$h_{o2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 3.00633$$

$$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{ps2} * F_{ywe2} = 3.00633$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{ps2} * F_{ywe2} = 3.00633$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$
 $c = \text{confinement factor} = 1.03496$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou,min = lb/ld = 1.00$

$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 656.8447$

with $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 788.2136$

$fy2 = 656.8447$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou,min = lb/lb,min = 1.00$

$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 656.8447$

with $Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.3333$

$fyv = 694.4444$

$suv = 0.032$

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 $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 694.4444$

with $Es_v = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15851815$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15851815$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.20360129$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.20360129$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_s, y_2$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.16187171$$

$$\mu = M_{Rc}(4.14) = 3.3051E+008$$

$$u = s_u(4.1) = 0.00010695$$

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:

$$u = 0.00010695$$

$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e(5.4c) = 0.02209223$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o1} = 340.00$$

$$h_{o1} = 340.00$$

$$b_{i21} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o2} = 192.00$$

$$h_{o2} = 192.00$$

$$b_{i22} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

 $A_{sec} = 160000.00$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su_1 = 0.4 \cdot esu_{1, \text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 656.8447$$

$$\text{with } Es_1 = (Es_{\text{jacket}} \cdot Asl, \text{ten, jacket} + Es_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 788.2136$$

$$fy_2 = 656.8447$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su_2 = 0.4 \cdot esu_{2, \text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 656.8447$$

$$\text{with } Es_2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esuv_{\text{nominal}} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{\text{nominal}}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 694.4444$$

$$\text{with } Es_v = (Es_{\text{jacket}} \cdot Asl, \text{mid, jacket} + Es_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.15851815$$

$$2 = Asl, \text{com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.15851815$$

$$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 34.15357$$

$$cc (5A.5, \text{TBDY}) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.20360129$$

$$2 = Asl, \text{com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.20360129$$

$$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / f_c) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->
 μ (4.9) = 0.16187171
 μ = MRc (4.14) = 3.3051E+008
 u = μ (4.1) = 0.00010695

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$
 $V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$
 $V_{Col0} = 454364.743$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$
 $\mu = 2.4805782E-012$
 $\nu = 1.5450773E-031$
 $d = 0.8 * h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:
 $V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$

V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
 $b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$
 $V_{Col0} = 454364.743$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.4805782E-012$

$\nu_u = 1.5450773E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.5625$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$b_w = 400.00$

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, $\phi = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -0.00349254$

Shear Force, $V2 = 4538.411$

Shear Force, $V3 = -2.4658913E-014$

Axial Force, $F = -5974.992$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

-Middle: $As_{l,mid} = 402.1239$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 829.3805$

-Compression: $As_{l,com,jacket} = 829.3805$

-Middle: $As_{l,mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $As_{l,com,core} = 307.8761$

-Middle: $As_{l,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.00566466$

$u = y + p = 0.00566466$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.00126409$ ((4.29), Biskinis Phd)

$My = 2.1541E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 29.75$

$N = 5974.992$

$E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 5.6801E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 1.0313993E-005$

with $f_y = 529.9948$

$d = 357.00$

$y = 0.28030823$

$A = 0.0188229$

$B = 0.01057976$

with $pt = 0.00442965$

$pc = 0.00796398$

$p_v = 0.00281599$

$N = 5974.992$

$b = 400.00$

" = 0.12044818

$y_{comp} = 2.2027040E-005$

with $fc = 33.00$

$E_c = 26999.444$

y = 0.27977394
A = 0.01864886
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.00440057

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1

shear control ratio $V_y E / V_{Co} I_{OE} = 0.48493697$

d = d_external = 357.00

s = s_external = 0.00

t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00442965

jacket: s1 = Av1*h1/(s1*Ag) = 0.00392699

Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction

h1 = 400.00

s1 = 100.00

core: s2 = Av2*h2/(s2*Ag) = 0.00050265

Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction

h2 = 200.00

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 = 5974.992

Ag = 160000.00

f_{cE} = (f_{c_jacket}*Area_{jacket}+ f_{c_core}*Area_{core})/section_area = 29.75

f_{yE} = (f_{y_ext_Long_Reinf}*Area_{ext_Long_Reinf}+ f_{y_int_Long_Reinf}*Area_{int_Long_Reinf})/Area_{Tot_Long_Rein} = 529.9948

f_{yE} = (f_{y_ext_Trans_Reinf}*Area_{ext_Trans_Reinf}+ f_{y_int_Trans_Reinf}*Area_{int_Trans_Reinf})/Area_{Tot_Trans_Rein} = 542.9472

pl = Area_{Tot_Long_Rein}/(b*d) = 0.01874396

b = 400.00

d = 357.00

f_{cE} = 29.75

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

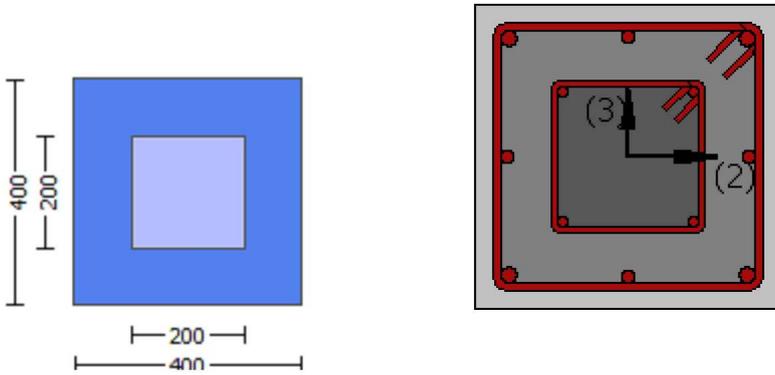
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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 Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.7019E+007$
Shear Force, $V_a = -5671.441$
EDGE -B-
Bending Moment, $M_b = -0.00436447$
Shear Force, $V_b = 5671.441$
BOTH EDGES
Axial Force, $F = -5974.539$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 1137.257$
-Compression: $A_{sc} = 1539.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1137.257$
-Compression: $A_{sl,com} = 1137.257$
-Middle: $A_{sl,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 327967.193$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 327967.193$
 $V_{CoI} = 327967.193$
 $k_n = 1.00$
displacement_ductility_demand = 0.02238637

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: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 22.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $M_u = 1.7019E+007$
 $V_u = 5671.441$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5974.539$
 $A_g = 160000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$
where:
 $V_{s1} = 251327.412$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 405571.497$
 $bw = 400.00$

displacement_ductility_demand is calculated as δ / y

- Calculation of δ / y for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation $\theta = 0.00028307$
 $y = (M_y * L_s / 3) / E_{eff} = 0.01264464$ ((4.29), Biskinis Phd)
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.89
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$
factor = 0.30
 $A_g = 160000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$
 $N = 5974.539$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 5.6801E+013$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0313992E-005$
with $f_y = 529.9948$
 $d = 357.00$
 $y = 0.28030815$
 $A = 0.0188229$
 $B = 0.01057976$
with $p_t = 0.00796398$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.539$
 $b = 400.00$
 $\rho = 0.12044818$
 $y_{comp} = 2.2027043E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.27977391$
 $A = 0.01864887$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Adequate Lap Length: $I_b / I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

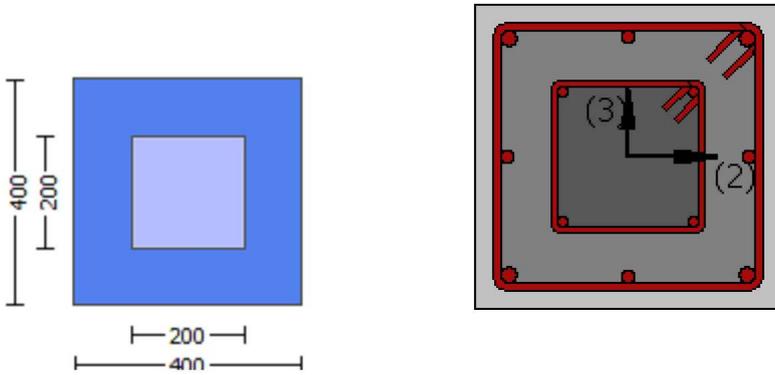
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 3.8733604E-032$
EDGE -B-
Shear Force, $V_b = -3.8733604E-032$
BOTH EDGES
Axial Force, $F = -5976.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{c,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.48493697$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3051E+008$
 $\mu_{u1+} = 3.3051E+008$, 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
 $\mu_{u1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.3051E+008$
 $\mu_{u2+} = 3.3051E+008$, 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
 $\mu_{u2-} = 3.3051E+008$, 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:
 $\mu_u = 0.00010695$
 $\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00944538$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00944538$
 $\mu_w (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$

bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008
ft1 = 788.2136
fy1 = 656.8447
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 788.2136
fy2 = 656.8447
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv , shv , ftv , fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.4444$$

$$\text{with } Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.15851815$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.15851815$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.20360129$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.20360129$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs_{y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$Mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00944538$$

$$we (5.4c) = 0.02209223$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$$

$$ase1 = 0.24250288$$

$$bo_1 = 340.00$$

ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008
ft1 = 788.2136
fy1 = 656.8447
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,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 = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 788.2136
fy2 = 656.8447
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y2, sh2,ft2,fy2, 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 = 656.8447

with $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $fy_v = 694.4444$
 $suv = 0.032$
 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
 $lo/lo_{min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15851815$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15851815$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.20360129$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.20360129$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16187171$
 $Mu = MRc (4.14) = 3.3051E+008$
 $u = su (4.1) = 0.00010695$

 Calculation of ratio lb/ld

 Adequate Lap Length: $lb/ld \geq 1$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010695$
 $Mu = 3.3051E+008$

 with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $we (5.4c) = 0.02209223$

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s2} = (f_{sjacket} \cdot A_{sl,com,jacket} + f_{s,core} \cdot A_{sl,com,core})/A_{sl,com} = 656.8447$

with $E_{s2} = (E_{sjacket} \cdot A_{sl,com,jacket} + E_{s,core} \cdot A_{sl,com,core})/A_{sl,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$s_{uv} = 0.032$

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

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$s_{uv} = 0.4 \cdot e_{suv,nominal} ((5.5), TBDY) = 0.032$

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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core})/A_{sl,mid} = 694.4444$

with $E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core})/A_{sl,mid} = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15851815$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15851815$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.20360129$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.20360129$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.16187171$

$\mu_u = MR_c (4.14) = 3.3051E+008$

$u = s_u (4.1) = 0.00010695$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_u

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010695$

$\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$cc (5A.5, TBDY) = 0.002$

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(c_u, cc) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.00944538$

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.24250288$

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = $\text{Max}(ase1, ase2) = 0.24250288$

bo_2 = 192.00

ho_2 = 192.00

bi2_2 = 147456.00

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.00633$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.00633$

ps1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir, 1} \cdot n_{s, 1} = 157.0796$

No stirups, $n_{s, 1} = 2.00$

h1 = 400.00

ps2 (internal) = $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir, 2} \cdot n_{s, 2} = 100.531$

No stirups, $n_{s, 2} = 2.00$

h2 = 200.00

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.00633$

ps1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00392699$

Ash1 = $A_{stir, 1} \cdot n_{s, 1} = 157.0796$

No stirups, $n_{s, 1} = 2.00$

h1 = 400.00

ps2 (internal) = $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00050265$

Ash2 = $A_{stir, 2} \cdot n_{s, 2} = 100.531$

No stirups, $n_{s, 2} = 2.00$

h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: $c_c = 0.00234957$

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = $0.4 \cdot esu1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} \cdot A_{sl, ten, jacket} + fs_{core} \cdot A_{sl, ten, core}) / A_{sl, ten} = 656.8447$

with $Es1 = (Es_{jacket} \cdot A_{sl, ten, jacket} + Es_{core} \cdot A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

$$su_2 = 0.4 * esu_2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_2_nominal = 0.08$,

For calculation of $esu_2_nominal$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 656.8447$$

$$\text{with } Es_2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 694.4444$$

$$\text{with } Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.15851815$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.15851815$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.20360129$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.20360129$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16187171$$

$$\mu_u = MR_c (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$$

$$V_{Col0} = 454364.743$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu_u = 1.0401148E-011$
 $V_u = 3.8733604E-032$
 $d = 0.8 \cdot h = 320.00$
 $Nu = 5976.808$
 $Ag = 160000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$
 where:
 $V_{s1} = 279252.68$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 454364.743$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu_u = 1.0401148E-011$
 $V_u = 3.8733604E-032$
 $d = 0.8 \cdot h = 320.00$
 $Nu = 5976.808$
 $Ag = 160000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$
 where:
 $V_{s1} = 279252.68$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
 $bw = 400.00$

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} >= 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -1.5450773E-031$

EDGE -B-

Shear Force, $V_b = 1.5450773E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t, \text{ten}} = 1137.257$

-Compression: $As_{c, \text{com}} = 1137.257$

-Middle: $As_{c, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.48493697$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 3.3051E+008$

$M_{u1+} = 3.3051E+008$, 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

$M_{u1-} = 3.3051E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 3.3051E+008$

$M_{u2+} = 3.3051E+008$, 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

$M_{u2-} = 3.3051E+008$, 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:

$\phi_u = 0.00010695$

$M_u = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

α (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00944538$

w_e (5.4c) = 0.02209223

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i2} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i2} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

p_{sh1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$

No stirups, $n_{s, 1} = 2.00$

$h_1 = 400.00$

p_{sh2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$

No stirups, $n_{s, 2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

p_{sh1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$

No stirups, $n_{s, 1} = 2.00$

$h_1 = 400.00$

p_{sh2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$

No stirups, $n_{s, 2} = 2.00$

$h_2 = 200.00$

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 fsy = 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 = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = $A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.20360129$

2 = $A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.20360129$

v = $A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < v_{s,y2} - LHS eq.(4.5) is satisfied

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 0.00010695

Mu = 3.3051E+008

with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.00126831

N = 5976.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00944538

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00944538

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = Max(ase1,ase2) = 0.24250288

bo_2 = 192.00

ho_2 = 192.00

bi2_2 = 147456.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699

Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699

Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265

Ash2 = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.20360129$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.20360129$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611263$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->
 $su (4.9) = 0.16187171$
 $Mu = MRc (4.14) = 3.3051E+008$
 $u = su (4.1) = 0.00010695$

 Calculation of ratio l_b/d

 Adequate Lap Length: $l_b/d \geq 1$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00010695$
 $Mu = 3.3051E+008$

 with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $w_e (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.00633$

 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$
 $ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2$ (internal) = $(A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$
 $ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2$ (internal) = $(Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

 $Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00234957$
 $c =$ confinement factor = 1.03496

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 788.2136$
 $fy1 = 656.8447$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou,min = lb/ld = 1.00$

$su1 = 0.4*esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 788.2136$
 $fy2 = 656.8447$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou,min = lb/lb,min = 1.00$

$su2 = 0.4*esu2_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447$

with $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.3333$
 $fyv = 694.4444$
 $suv = 0.032$

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 $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$

with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$

$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.20360129$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.20360129$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.16187171$$

$$\mu_u = M_{Rc} (4.14) = 3.3051E+008$$

$$u = s_u (4.1) = 0.00010695$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{u2} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e (5.4c) = 0.02209223$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.00633$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 3.00633
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00392699
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00050265
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

Asec = 160000.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.4444

fywe₂ = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 788.2136

fy₁ = 656.8447

su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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} = 656.8447

with Es₁ = (Es_{jacket}*Asl_{ten,jacket} + Es_{core}*Asl_{ten,core})/Asl_{ten} = 200000.00

y₂ = 0.0025

sh₂ = 0.008

ft₂ = 788.2136

fy₂ = 656.8447

su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_{b,min} = 1.00

su₂ = 0.4*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} = 656.8447

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 = 833.3333

fy_v = 694.4444

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 = 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/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs_v = (fs_{jacket}*Asl_{mid,jacket} + fs_{mid}*Asl_{mid,core})/Asl_{mid} = 694.4444

with Es_v = (Es_{jacket}*Asl_{mid,jacket} + Es_{mid}*Asl_{mid,core})/Asl_{mid} = 200000.00

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.15851815$$

$$2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.15851815$$

$$v = A_{s1,mid}/(b*d)*(f_{sv}/f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.15357$$

$$c_c (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.20360129$$

$$2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.20360129$$

$$v = A_{s1,mid}/(b*d)*(f_{sv}/f_c) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.16187171$$

$$\mu_u = M R_c (4.14) = 3.3051E+008$$

$$u = s_u (4.1) = 0.00010695$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 454364.743$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 29.75$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.4805782E-012$$

$$V_u = 1.5450773E-031$$

$$d = 0.8 * h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279252.68$$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.3125$$

$V_{s2} = 0.00$ is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

V_{s2} is multiplied by $Col2 = 0.00$

$$s/d = 1.5625$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 463788.751$$

bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 454364.743

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 454364.743

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.4805782E-012

Vu = 1.5450773E-031

d = 0.8 * h = 320.00

Nu = 5976.808

Ag = 160000.00

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

d = 320.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 100.00

V_{s1} is multiplied by Col1 = 1.00

s/d = 0.3125

$V_{s2} = 0.00$ is calculated for core, with:

d = 160.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

V_{s2} is multiplied by Col2 = 0.00

s/d = 1.5625

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/d >= 1$)
 No FRP Wrapping

 Stepwise Properties

Bending Moment, $M = -5.9427557E-011$
 Shear Force, $V_2 = -5671.441$
 Shear Force, $V_3 = 3.0815100E-014$
 Axial Force, $F = -5974.539$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 1137.257$
 -Compression: $A_{sc} = 1539.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1137.257$
 -Compression: $A_{sc,com} = 1137.257$
 -Middle: $A_{sc,mid} = 402.1239$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,jacket} = 829.3805$
 -Compression: $A_{sc,com,jacket} = 829.3805$
 -Middle: $A_{sc,mid,jacket} = 402.1239$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,core} = 307.8761$
 -Compression: $A_{sc,com,core} = 307.8761$
 -Middle: $A_{sc,mid,core} = 0.00$
 Mean Diameter of Tension Reinforcement, $DbL = 16.80$

 Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = \rho \cdot u = 0.03951044$
 $u = \rho \cdot y + p = 0.03951044$

 - Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00632045$ ((4.29), Biskinis Phd)
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.7040E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 29.75$
 $N = 5974.539$
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 5.6801E+013$

 Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0313992E-005$
 with $f_y = 529.9948$

$d = 357.00$
 $y = 0.28030815$
 $A = 0.0188229$
 $B = 0.01057976$
 with $pt = 0.00442965$
 $pc = 0.00796398$
 $pv = 0.00281599$
 $N = 5974.539$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.2027043E-005$
 with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.27977391$
 $A = 0.01864887$
 $B = 0.01050082$
 with $Es = 200000.00$

 Calculation of ratio lb/d

 Adequate Lap Length: $lb/d \geq 1$

 - Calculation of p -

 From table 10-8: $p = 0.03319$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/d \geq 1$

shear control ratio $VyE/ColOE = 0.48493697$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00442965$

jacket: $s1 = Av1*h1/(s1*Ag) = 0.00392699$

$Av1 = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h1 = 400.00$

$s1 = 100.00$

core: $s2 = Av2*h2/(s2*Ag) = 0.00050265$

$Av2 = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h2 = 200.00$

$s2 = 250.00$

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.

$NUD = 5974.539$

$Ag = 160000.00$

$fcE = (fc_{jacket}*Area_{jacket} + fc_{core}*Area_{core})/section_area = 29.75$

$fyIE = (fy_{ext_Long_Reinf}*Area_{ext_Long_Reinf} + fy_{int_Long_Reinf}*Area_{int_Long_Reinf})/Area_{Tot_Long_Rein} = 529.9948$

$fyTE = (fy_{ext_Trans_Reinf}*Area_{ext_Trans_Reinf} + fy_{int_Trans_Reinf}*Area_{int_Trans_Reinf})/Area_{Tot_Trans_Rein} = 542.9472$

$pl = Area_{Tot_Long_Rein}/(b*d) = 0.01874396$

$b = 400.00$

$d = 357.00$

$fcE = 29.75$

 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

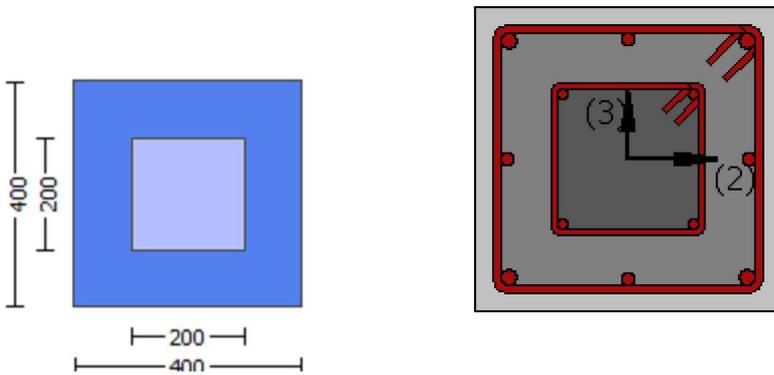
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -5.9427557E-011$
Shear Force, $V_a = 3.0815100E-014$
EDGE -B-
Bending Moment, $M_b = -3.2971707E-011$
Shear Force, $V_b = -3.0815100E-014$
BOTH EDGES
Axial Force, $F = -5974.539$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 1137.257$
-Compression: $A_{sc} = 1539.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1137.257$
-Compression: $A_{sc,com} = 1137.257$
-Middle: $A_{s,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 404606.974$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 404606.974$
 $V_{CoI} = 404606.974$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \phi_f y d/s$ ' is replaced by ' $V_s + \phi_f V_f$ '
where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_c_jacket \cdot Area_jacket + f'_c_core \cdot Area_core) / Area_section = 22.75$, but $f'_c^{0.5} \leq 8.3$
MPa ((22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 5.9427557E-011$
 $V_u = 3.0815100E-014$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5974.539$
 $A_g = 160000.00$
From ((11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$
where:
 $V_{s1} = 251327.412$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$

$f_y = 400.00$
 $s = 250.00$
Vs2 is multiplied by Col2 = 0.00
 $s/d = 1.5625$
 $V_f((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 405571.497$
 $bw = 400.00$

displacement_ductility_demand is calculated as δ / y

- Calculation of δ / y for END A -
for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 2.5605764E-021$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00632045$ ((4.29), Biskinis Phd))
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$
 $factor = 0.30$
 $A_g = 160000.00$
Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 29.75$
 $N = 5974.539$
 $E_c * I_g = E_c_jacket * I_g_jacket + E_c_core * I_g_core = 5.6801E+013$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0313992E-005$
with $f_y = 529.9948$
 $d = 357.00$
 $y = 0.28030815$
 $A = 0.0188229$
 $B = 0.01057976$
with $pt = 0.00796398$
 $pc = 0.00796398$
 $pv = 0.00281599$
 $N = 5974.539$
 $b = 400.00$
 $\rho = 0.12044818$
 $y_{comp} = 2.2027043E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.27977391$
 $A = 0.01864887$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio l_b / d

Adequate Lap Length: $l_b / d \geq 1$

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

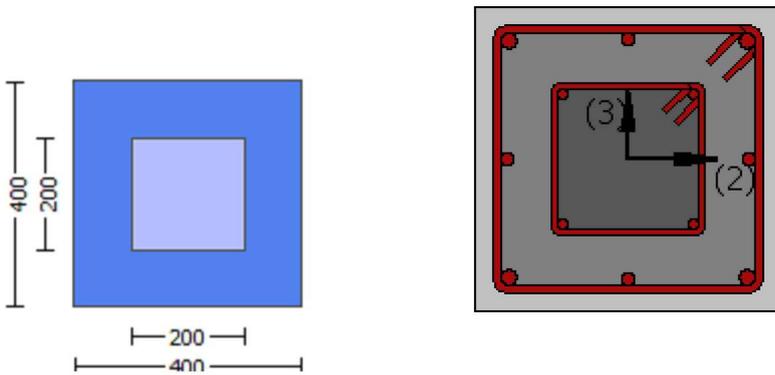
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.03496
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 3.8733604E-032$
EDGE -B-
Shear Force, $V_b = -3.8733604E-032$
BOTH EDGES
Axial Force, $F = -5976.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.3051E+008$
 $Mu_{1+} = 3.3051E+008$, 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
 $Mu_{1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.3051E+008$
 $Mu_{2+} = 3.3051E+008$, 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
 $Mu_{2-} = 3.3051E+008$, 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:
 $\phi_u = 0.00010695$
 $Mu = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 ϕ_o (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_o) = 0.00944538$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.00944538$

w_e (5.4c) = 0.02209223
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$
 $a_{se1} = 0.24250288$
 $b_{o_1} = 340.00$
 $h_{o_1} = 340.00$
 $b_{i2_1} = 462400.00$
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$
 $b_{o_2} = 192.00$
 $h_{o_2} = 192.00$
 $b_{i2_2} = 147456.00$
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$
 $ps1$ (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $ps2$ (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$
 $ps1$ (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $ps2$ (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$

$f_{ywe1} = 694.4444$
 $f_{ywe2} = 555.5556$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$
 $c = \text{confinement factor} = 1.03496$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 788.2136$
 $fy_1 = 656.8447$
 $su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$l_o / l_{ou, \min} = l_b / l_d = 1.00$

$su_1 = 0.4 * esu_{1, \text{nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{1, \text{nominal}} = 0.08$,

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fs_1 = fs_1 / 1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 656.8447$

with $Es_1 = (E_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + E_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 788.2136$
 $fy_2 = 656.8447$
 $su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 1.00$

$su_2 = 0.4 * esu_{2, \text{nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{2, \text{nominal}} = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 656.8447$

with $Es_2 = (Es_{jacket} \cdot Asl_{,com,jacket} + Es_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$suv = 0.032$

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, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_v = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 694.4444$

with $Es_v = (Es_{jacket} \cdot Asl_{,mid,jacket} + Es_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 200000.00$

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15851815$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15851815$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.20360129$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.20360129$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16187171

$Mu = MRc$ (4.14) = 3.3051E+008

$u = su$ (4.1) = 0.00010695

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010695$

$Mu = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$fc = 33.00$

co (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.00944538$

w_e (5.4c) = 0.02209223

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o_1} = 340.00$

$h_{o_1} = 340.00$

$b_{i2_1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o_2} = 192.00$

$h_{o_2} = 192.00$

$b_{i2_2} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$

 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 400.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 200.00$

 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 400.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 200.00$

 $A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 788.2136$

$fy_1 = 656.8447$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 1.00$

$su_1 = 0.4 * esu_{1, \text{nominal}} ((5.5), \text{TBDY}) = 0.032$

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 $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 656.8447$

with $Es_1 = (E_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + E_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 788.2136$

$fy_2 = 656.8447$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,

For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{sv} = f_{sv}/1.2$, 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 $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.4444$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.15851815$$

$$2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.15851815$$

$$v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.15357$$

$$c_c (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.20360129$$

$$2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.20360129$$

$$v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.16187171$$

$$\mu_u = M_{Rc} (4.14) = 3.3051E+008$$

$$u = s_u (4.1) = 0.00010695$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u2+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $we (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1,ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633$

$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633$
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633$
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$
 $c = confinement\ factor = 1.03496$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 788.2136$
 $fy1 = 656.8447$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou,min = lb/ld = 1.00$

$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 788.2136$
 $fy2 = 656.8447$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{s_u2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_u2,nominal} = 0.08$,

For calculation of $e_{s_u2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{s_y2} = f_{s_2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_2} = (f_{s,jacket} * A_{s_l,com,jacket} + f_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 656.8447$$

$$\text{with } E_{s_2} = (E_{s,jacket} * A_{s_l,com,jacket} + E_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$s_{u_v} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_d = 1.00$$

$$s_{u_v} = 0.4 * e_{s_{u_v},nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_{u_v},nominal} = 0.08$,

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY

For calculation of $e_{s_{u_v},nominal}$ and y_v, sh_v, ft_v, fy_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, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_v} = (f_{s,jacket} * A_{s_l,mid,jacket} + f_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 694.4444$$

$$\text{with } E_{s_v} = (E_{s,jacket} * A_{s_l,mid,jacket} + E_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 200000.00$$

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.15851815$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.15851815$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.20360129$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.20360129$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.16187171$$

$$\mu_u = M R_c (4.14) = 3.3051E+008$$

$$u = s_u (4.1) = 0.00010695$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_u -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $we (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, min * Fywe = Min(psh, x * Fywe, psh, y * Fywe) = 3.00633$

$psh, x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh, y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$

$fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$
 $c = confinement\ factor = 1.03496$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 788.2136$
 $fy1 = 656.8447$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 656.8447$

with $Es1 = (Es, jacket * Asl, ten, jacket + Es, core * Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 656.8447$$

$$\text{with } Es2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 694.4444$$

$$\text{with } Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15851815$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15851815$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.20360129$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.20360129$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

---->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 454364.743$

Calculation of Shear Strength at edge 1, $Vr1 = 454364.743$

$$Vr1 = VCoI ((10.3), ASCE 41-17) = knl * VCoIO$$

$$VCoIO = 454364.743$$

$$knl = 1 \text{ (zero step-static loading)}$$

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0401148E-011$

$\nu_u = 3.8733604E-032$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 1.5625$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 454364.743$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0401148E-011$

$\nu_u = 3.8733604E-032$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 1.5625$

Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 463788.751
bw = 400.00

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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
#####

External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03496
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -1.5450773E-031
EDGE -B-
Shear Force, Vb = 1.5450773E-031
BOTH EDGES
Axial Force, F = -5976.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Asc = 2676.637

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl,ten = 1137.257$

-Compression: $Asl,com = 1137.257$

-Middle: $Asl,mid = 402.1239$

Calculation of Shear Capacity ratio , $Ve/Vr = 0.48493697$

Member Controlled by Flexure ($Ve/Vr < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $Ve = (Mpr1 + Mpr2)/ln = 220338.264$

with

$Mpr1 = \text{Max}(Mu1+, Mu1-) = 3.3051E+008$

$Mu1+ = 3.3051E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu1- = 3.3051E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr2 = \text{Max}(Mu2+, Mu2-) = 3.3051E+008$

$Mu2+ = 3.3051E+008$, 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

$Mu2- = 3.3051E+008$, 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:

$\phi_u = 0.00010695$

$Mu = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00944538$

w_e (5.4c) = 0.02209223

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$

$ase1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 3.00633$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$

$ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2$ (internal) = $(A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.00633$

$ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$

$$\text{Ash1} = \text{Astir}_1 * \text{ns}_1 = 157.0796$$

$$\text{No stirups, ns}_1 = 2.00$$

$$h1 = 400.00$$

$$\text{ps2 (internal)} = (\text{Ash2} * h2 / s2) / \text{Asec} = 0.00050265$$

$$\text{Ash2} = \text{Astir}_2 * \text{ns}_2 = 100.531$$

$$\text{No stirups, ns}_2 = 2.00$$

$$h2 = 200.00$$

$$\text{Asec} = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$\text{fywe1} = 694.4444$$

$$\text{fywe2} = 555.5556$$

$$\text{fce} = 33.00$$

$$\text{From } ((5.A5), \text{TBDY}), \text{TBDY: cc} = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y1 = 0.0025$$

$$\text{sh1} = 0.008$$

$$\text{ft1} = 788.2136$$

$$\text{fy1} = 656.8447$$

$$\text{su1} = 0.032$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 1.00$$

$$\text{su1} = 0.4 * \text{esu1_nominal} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, \text{sh1,ft1,fy1, are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with fs1} = (\text{fs,jacket} * \text{Asl,ten,jacket} + \text{fs,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 656.8447$$

$$\text{with Es1} = (\text{Es,jacket} * \text{Asl,ten,jacket} + \text{Es,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 200000.00$$

$$y2 = 0.0025$$

$$\text{sh2} = 0.008$$

$$\text{ft2} = 788.2136$$

$$\text{fy2} = 656.8447$$

$$\text{su2} = 0.032$$

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

$$\text{lo/lou,min} = \text{lb/lb,min} = 1.00$$

$$\text{su2} = 0.4 * \text{esu2_nominal} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, \text{sh1,ft1,fy1, are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with fs2} = (\text{fs,jacket} * \text{Asl,com,jacket} + \text{fs,core} * \text{Asl,com,core}) / \text{Asl,com} = 656.8447$$

$$\text{with Es2} = (\text{Es,jacket} * \text{Asl,com,jacket} + \text{Es,core} * \text{Asl,com,core}) / \text{Asl,com} = 200000.00$$

$$yv = 0.0025$$

$$\text{shv} = 0.008$$

$$\text{ftv} = 833.3333$$

$$\text{fyv} = 694.4444$$

$$\text{suv} = 0.032$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 1.00$$

$$\text{suv} = 0.4 * \text{esuv_nominal} ((5.5), \text{TBDY}) = 0.032$$

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.

$$y1, \text{sh1,ft1,fy1, are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with fsv} = (\text{fs,jacket} * \text{Asl,mid,jacket} + \text{fs,mid} * \text{Asl,mid,core}) / \text{Asl,mid} = 694.4444$$

$$\text{with Esv} = (\text{Es,jacket} * \text{Asl,mid,jacket} + \text{Es,mid} * \text{Asl,mid,core}) / \text{Asl,mid} = 200000.00$$

$$1 = \text{Asl,ten} / (\text{b} * \text{d}) * (\text{fs1} / \text{fc}) = 0.15851815$$

$$2 = \text{Asl,com} / (\text{b} * \text{d}) * (\text{fs2} / \text{fc}) = 0.15851815$$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05925912$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.20360129$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.20360129$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611263$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $s_u (4.9) = 0.16187171$
 $M_u = M_{Rc} (4.14) = 3.3051E+008$
 $u = s_u (4.1) = 0.00010695$

 Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{u1} -

 Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00010695$
 $\mu_u = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.00944538$
 $w_e (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $p_{sh,min}*F_{ywe} = \text{Min}(p_{sh,x}*F_{ywe}, p_{sh,y}*F_{ywe}) = 3.00633$

 $p_{sh,x}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 3.00633$
 $ps1 (external) = (A_{sh1}*h1/s1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1}*n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (A_{sh2}*h2/s2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2}*n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h2 = 200.00$

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 3.00633
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00392699
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00050265
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

Asec = 160000.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.4444

fywe₂ = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957

c = confinement factor = 1.03496

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 788.2136

fy₁ = 656.8447

su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su₁ = 0.4*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} = 656.8447

with Es₁ = (Es_{jacket}*Asl_{ten,jacket} + Es_{core}*Asl_{ten,core})/Asl_{ten} = 200000.00

y₂ = 0.0025

sh₂ = 0.008

ft₂ = 788.2136

fy₂ = 656.8447

su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su₂ = 0.4*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} = 656.8447

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 = 833.3333

fy_v = 694.4444

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 = 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.

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} = 694.4444

$$\text{with } Esv = (Es_{\text{jacket}} \cdot Asl_{\text{mid,jacket}} + Es_{\text{mid}} \cdot Asl_{\text{mid,core}}) / Asl_{\text{mid}} = 200000.00$$

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs1 / fc) = 0.15851815$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs2 / fc) = 0.15851815$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 34.15357$$

$$cc \text{ (5A.5, TBDY)} = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs1 / fc) = 0.20360129$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs2 / fc) = 0.20360129$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su \text{ (4.9)} = 0.16187171$$

$$\text{Mu} = \text{MRc} \text{ (4.14)} = 3.3051\text{E}+008$$

$$u = su \text{ (4.1)} = 0.00010695$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu_{2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$\text{Mu} = 3.3051\text{E}+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$fc = 33.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00944538$$

$$we \text{ (5.4c)} = 0.02209223$$

$$ase \text{ ((5.4d), TBDY)} = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.24250288$$

$$ase1 = 0.24250288$$

$$bo_1 = 340.00$$

$$ho_1 = 340.00$$

$$bi2_1 = 462400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.24250288$$

$$bo_2 = 192.00$$

$$ho_2 = 192.00$$

$$bi2_2 = 147456.00$$

$$psh_{\text{min}} \cdot Fy_{we} = \text{Min}(psh_x \cdot Fy_{we}, psh_y \cdot Fy_{we}) = 3.00633$$

$$psh_x \cdot Fy_{we} = psh1 \cdot Fy_{we1} + ps2 \cdot Fy_{we2} = 3.00633$$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00050265$$

Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15851815$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.15851815$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.20360129$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.20360129$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.16187171$

$Mu = MRc (4.14) = 3.3051E+008$

$u = su (4.1) = 0.00010695$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010695$

$Mu = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00944538$

we (5.4c) = 0.02209223

$ase ((5.4d), TBDY) = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.24250288$

$ase_1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi_2_1 = 462400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi_2_2 = 147456.00$

$psh_{,min} \cdot F_{ywe} = \text{Min}(psh_{,x} \cdot F_{ywe}, psh_{,y} \cdot F_{ywe}) = 3.00633$

$psh_{,x} \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 3.00633$

ps_1 (external) = $(Ash_1 \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00050265
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 3.00633
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00392699
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00050265
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

Asec = 160000.00
s₁ = 100.00
s₂ = 250.00
fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y₁ = 0.0025
sh₁ = 0.008
ft₁ = 788.2136
fy₁ = 656.8447
su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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} = 656.8447

with Es₁ = (Es_{jacket}*Asl_{ten,jacket} + Es_{core}*Asl_{ten,core})/Asl_{ten} = 200000.00

y₂ = 0.0025
sh₂ = 0.008
ft₂ = 788.2136
fy₂ = 656.8447
su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_{b,min} = 1.00

su₂ = 0.4*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} = 656.8447

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 = 833.3333
fy_v = 694.4444
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/l_d = 1.00

su_v = 0.4*esuv_{nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv,ftv,fyv , it is considered
 characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$
 with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 fcc (5A.2, TBDY) = 34.15357
 cc (5A.5, TBDY) = 0.00234957
 $c =$ confinement factor = 1.03496
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

---->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied

---->
 su (4.9) = 0.16187171
 $Mu = MRc$ (4.14) = 3.3051E+008
 $u = su$ (4.1) = 0.00010695

 Calculation of ratio lb/d

 Adequate Lap Length: $lb/d \geq 1$

 Calculation of Shear Strength $Vr = Min(Vr1,Vr2) = 454364.743$

 Calculation of Shear Strength at edge 1, $Vr1 = 454364.743$
 $Vr1 = VCol$ ((10.3), ASCE 41-17) = $knl*VColO$
 $VColO = 454364.743$
 $knl = 1$ (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: $fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 29.75$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/d = 2.00$
 $Mu = 2.4805782E-012$
 $Vu = 1.5450773E-031$
 $d = 0.8*h = 320.00$
 $Nu = 5976.808$
 $Ag = 160000.00$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 = 279252.68$
 where:
 $Vs1 = 279252.68$ is calculated for jacket, with:
 $d = 320.00$
 $Av = 157079.633$
 $fy = 555.5556$
 $s = 100.00$
 $Vs1$ is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $Vs2 = 0.00$ is calculated for core, with:
 $d = 160.00$

Av = 100530.965

fy = 444.4444

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 463788.751

bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 454364.743

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 454364.743

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 = 29.75, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.4805782E-012

Vu = 1.5450773E-031

d = 0.8*h = 320.00

Nu = 5976.808

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279252.68

where:

Vs1 = 279252.68 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 463788.751

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d > 1$)
 No FRP Wrapping

 Stepwise Properties

Bending Moment, $M = -1.7019E+007$
 Shear Force, $V_2 = -5671.441$
 Shear Force, $V_3 = 3.0815100E-014$
 Axial Force, $F = -5974.539$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 1137.257$
 -Compression: $A_{sc} = 1539.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1137.257$
 -Compression: $A_{sc,com} = 1137.257$
 -Middle: $A_{sc,mid} = 402.1239$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,jacket} = 829.3805$
 -Compression: $A_{sc,com,jacket} = 829.3805$
 -Middle: $A_{sc,mid,jacket} = 402.1239$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,core} = 307.8761$
 -Compression: $A_{sc,com,core} = 307.8761$
 -Middle: $A_{sc,mid,core} = 0.00$
 Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = u = 0.04583464$
 $u = y + p = 0.04583464$

 - Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01264464$ ((4.29), Biskinis Phd))
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.89
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$
 $N = 5974.539$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 5.6801E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.0313992\text{E}-005$
with $f_y = 529.9948$
 $d = 357.00$
 $y = 0.28030815$
 $A = 0.0188229$
 $B = 0.01057976$
with $p_t = 0.00442965$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.539$
 $b = 400.00$
 $\rho = 0.12044818$
 $y_{\text{comp}} = 2.2027043\text{E}-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.27977391$
 $A = 0.01864887$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

- Calculation of ρ -

From table 10-8: $\rho = 0.03319$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 0.48493697$

$d = d_{\text{external}} = 357.00$

$s = s_{\text{external}} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$

jacket: $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 400.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 200.00$

$s_2 = 250.00$

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.

$N_{UD} = 5974.539$

$A_g = 160000.00$

$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 29.75$

$f_{yE} = (f_{y_{\text{ext_Long_Reinf}}} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_{y_{\text{int_Long_Reinf}}} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 529.9948$

$f_{yE} = (f_{y_{\text{ext_Trans_Reinf}}} \cdot \text{Area}_{\text{ext_Trans_Reinf}} + f_{y_{\text{int_Trans_Reinf}}} \cdot \text{Area}_{\text{int_Trans_Reinf}}) / \text{Area}_{\text{Tot_Trans_Rein}} = 542.9472$

$\rho_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01874396$

$b = 400.00$

$d = 357.00$

$f_{cE} = 29.75$

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

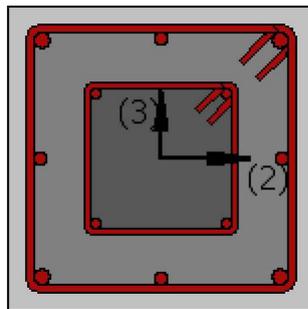
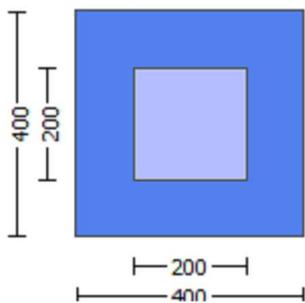
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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 Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.7019E+007$

Shear Force, $V_a = -5671.441$

EDGE -B-

Bending Moment, $M_b = -0.00436447$

Shear Force, $V_b = 5671.441$

BOTH EDGES

Axial Force, $F = -5974.539$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1137.257$

-Compression: $A_{st,com} = 1137.257$

-Middle: $A_{st,mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 404606.974$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 404606.974$

$V_{CoI} = 404606.974$

$k_n = 1.00$

displacement_ductility_demand = 0.11850389

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: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 22.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 0.00436447$

$V_u = 5671.441$

$d = 0.8 \cdot h = 320.00$

$N_u = 5974.539$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$

where:

$V_{s1} = 251327.412$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 500.00$
 $s = 100.00$
 Vs1 is multiplied by Col1 = 1.00
 $s/d = 0.3125$
 Vs2 = 0.00 is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 Vs2 is multiplied by Col2 = 0.00
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 405571.497$
 $b_w = 400.00$

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 = 0.0001498
 $y = (M_y * L_s / 3) / E_{eff} = 0.00126409$ ((4.29), Biskinis Phd)
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$
 $N = 5974.539$
 $E_c * I_g = E_c_{jacket} * I_g_{jacket} + E_c_{core} * I_g_{core} = 5.6801E+013$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0313992E-005$
 with $f_y = 529.9948$
 $d = 357.00$
 $y = 0.28030815$
 $A = 0.0188229$
 $B = 0.01057976$
 with $p_t = 0.00796398$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.539$
 $b = 400.00$
 $\rho = 0.12044818$
 $y_{comp} = 2.2027043E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.27977391$
 $A = 0.01864887$
 $B = 0.01050082$
 with $E_s = 200000.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2

Integration Section: (b)

Calculation No. 14

column C1, Floor 1

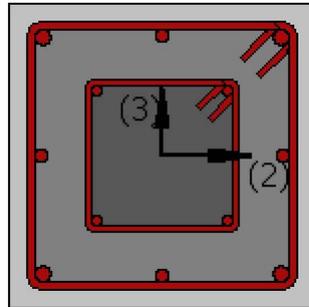
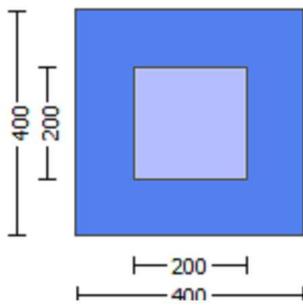
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$
 #####
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.03496
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou, \min} \geq 1$)
 No FRP Wrapping

 Stepwise Properties

 At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 3.8733604E-032$
 EDGE -B-
 Shear Force, $V_b = -3.8733604E-032$
 BOTH EDGES
 Axial Force, $F = -5976.808$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 2676.637$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st, \text{ten}} = 1137.257$
 -Compression: $A_{st, \text{com}} = 1137.257$
 -Middle: $A_{st, \text{mid}} = 402.1239$

 Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
 with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3051E+008$
 $M_{u1+} = 3.3051E+008$, 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
 $M_{u1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3051E+008$
 $M_{u2+} = 3.3051E+008$, 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
 $M_{u2-} = 3.3051E+008$, 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:
 $\phi_u = 0.00010695$
 $M_u = 3.3051E+008$

 with full section properties:
 $b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$

$N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $we (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1,ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633$

$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633$
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633$
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$
 $c = confinement\ factor = 1.03496$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 788.2136$
 $fy1 = 656.8447$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou,min = lb/ld = 1.00$

$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1,ft1,fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 788.2136$
 $fy2 = 656.8447$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{s_u2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_u2,nominal} = 0.08$,

For calculation of $e_{s_u2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{s_y2} = f_{s_2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_2} = (f_{s,jacket} * A_{s_l,com,jacket} + f_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 656.8447$$

$$\text{with } E_{s_2} = (E_{s,jacket} * A_{s_l,com,jacket} + E_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$s_{u_v} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_d = 1.00$$

$$s_{u_v} = 0.4 * e_{s_{u_v},nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_{u_v},nominal} = 0.08$,

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY

For calculation of $e_{s_{u_v},nominal}$ and y_v, sh_v, ft_v, fy_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, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_v} = (f_{s,jacket} * A_{s_l,mid,jacket} + f_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 694.4444$$

$$\text{with } E_{s_v} = (E_{s,jacket} * A_{s_l,mid,jacket} + E_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 200000.00$$

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.15851815$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.15851815$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.20360129$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.20360129$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.16187171$$

$$\mu_u = M R_c (4.14) = 3.3051E+008$$

$$u = s_u (4.1) = 0.00010695$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u1} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$\mu_u = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $we (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, min * Fywe = Min(psh, x * Fywe, psh, y * Fywe) = 3.00633$

$psh, x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh, y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.00633$
 $ps1 (external) = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$

$fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00234957$
 $c = confinement\ factor = 1.03496$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 788.2136$
 $fy1 = 656.8447$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 656.8447$

with $Es1 = (Es, jacket * Asl, ten, jacket + Es, core * Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 656.8447$$

$$\text{with } Es2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 694.4444$$

$$\text{with } Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15851815$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15851815$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.20360129$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.20360129$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

---->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

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:

$$u = 0.00010695$$

$$Mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e (5.4c) = 0.02209223$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{o, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_1_{\text{nominal}} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{\text{nominal}} = 0.08,$$

For calculation of esu_1_{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.

$$\text{with } fs_1 = (fs_{\text{jacket}} * A_{sl, \text{jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 656.8447$$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 788.2136$
 $fy_2 = 656.8447$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 \cdot esu_2_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2_{nominal} = 0.08$,
 For calculation of $esu_2_{nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2 / 1.2$, 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 $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 656.8447$
 with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $fy_v = 694.4444$
 $su_v = 0.032$
 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 $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.15851815$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.15851815$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / f_c) = 0.05925912$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.20360129$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.20360129$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / f_c) = 0.07611263$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16187171$
 $M_u = MR_c (4.14) = 3.3051E+008$
 $u = su (4.1) = 0.00010695$

 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:

$$u = 0.00010695$$

$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00944538$$

$$w_e(5.4c) = 0.02209223$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o1} = 340.00$$

$$h_{o1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o2} = 192.00$$

$$h_{o2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1, \text{nominal}} = 0.08,$$

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 656.8447$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 788.2136$

$fy_2 = 656.8447$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{d,min} = 1.00$

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 656.8447$

with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_v = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 694.4444$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15851815$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15851815$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.20360129$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.20360129$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.16187171$

$Mu = MRc (4.14) = 3.3051E+008$

$u = su (4.1) = 0.00010695$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I * V_{Col0}$

$V_{Col0} = 454364.743$

$k_n I = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu = 1.0401148E-011$

$\nu = 3.8733604E-032$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.5625$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I * V_{Col0}$

$V_{Col0} = 454364.743$

$k_n I = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu = 1.0401148E-011$

$\nu = 3.8733604E-032$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$ is calculated for core, with:

d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 463788.751
bw = 400.00

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, γ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$

External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03496
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -1.5450773E-031
EDGE -B-

Shear Force, $V_b = 1.5450773E-031$
BOTH EDGES
Axial Force, $F = -5976.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{c,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.3051E+008$
 $Mu_{1+} = 3.3051E+008$, 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
 $Mu_{1-} = 3.3051E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.3051E+008$
 $Mu_{2+} = 3.3051E+008$, 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
 $Mu_{2-} = 3.3051E+008$, 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:
 $\phi_u = 0.00010695$
 $M_u = 3.3051E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha_1 (5A.5, TBDY) = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00944538$

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.24250288$

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = $\text{Max}(ase_1, ase_2) = 0.24250288$

bo_2 = 192.00

ho_2 = 192.00

bi2_2 = 147456.00

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.00633$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$

ps1 (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 400.00$

ps2 (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008
ft1 = 788.2136
fy1 = 656.8447
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 788.2136
fy2 = 656.8447
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.3333
fyv = 694.4444
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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15851815$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.15851815$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.20360129$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.20360129$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.16187171$

$Mu = MRc (4.14) = 3.3051E+008$

$u = su (4.1) = 0.00010695$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010695$

$Mu = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00944538$

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.24250288$

$ase_1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi_2_1 = 462400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi_2_2 = 147456.00$

$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.00633$

$psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 3.00633$

ps_1 (external) = $(Ash_1 \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00050265
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 3.00633
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00392699
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00050265
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

Asec = 160000.00
s₁ = 100.00
s₂ = 250.00
fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y₁ = 0.0025
sh₁ = 0.008
ft₁ = 788.2136
fy₁ = 656.8447
su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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}*As_{l,ten,jacket} + fs_{core}*As_{l,ten,core})/As_{l,ten} = 656.8447

with Es₁ = (Es_{jacket}*As_{l,ten,jacket} + Es_{core}*As_{l,ten,core})/As_{l,ten} = 200000.00

y₂ = 0.0025
sh₂ = 0.008
ft₂ = 788.2136
fy₂ = 656.8447
su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_{b,min} = 1.00

su₂ = 0.4*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}*As_{l,com,jacket} + fs_{core}*As_{l,com,core})/As_{l,com} = 656.8447

with Es₂ = (Es_{jacket}*As_{l,com,jacket} + Es_{core}*As_{l,com,core})/As_{l,com} = 200000.00

y_v = 0.0025
sh_v = 0.008
ft_v = 833.3333
fy_v = 694.4444
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/l_d = 1.00

su_v = 0.4*esuv_{nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv,ftv,fyv , it is considered
 characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket}*Asl_{mid,jacket} + fs_{mid}*Asl_{mid,core})/Asl_{mid} = 694.4444$
 with $Esv = (Es_{jacket}*Asl_{mid,jacket} + Es_{mid}*Asl_{mid,core})/Asl_{mid} = 200000.00$
 $1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.15851815$
 $2 = Asl_{com}/(b*d)*(fs2/fc) = 0.15851815$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.05925912$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 fcc (5A.2, TBDY) = 34.15357
 cc (5A.5, TBDY) = 0.00234957
 $c =$ confinement factor = 1.03496
 $1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.20360129$
 $2 = Asl_{com}/(b*d)*(fs2/fc) = 0.20360129$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

---->
 $v < vs_{y2}$ - LHS eq.(4.5) is satisfied

---->
 su (4.9) = 0.16187171
 $Mu = MRc$ (4.14) = 3.3051E+008
 $u = su$ (4.1) = 0.00010695

 Calculation of ratio lb/l_d

 Adequate Lap Length: $lb/l_d \geq 1$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010695$
 $Mu = 3.3051E+008$

 with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $fc = 33.00$
 co (5A.5, TBDY) = 0.002
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 w_e (5.4c) = 0.02209223
 ase ((5.4d), TBDY) = $(ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh_{min}*Fy_{we} = Min(psh_x*Fy_{we}, psh_y*Fy_{we}) = 3.00633$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008
ft1 = 788.2136
fy1 = 656.8447
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 788.2136
fy2 = 656.8447
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.3333
fyv = 694.4444
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

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 = 0.00010695

Mu = 3.3051E+008

with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.00126831

N = 5976.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00944538

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00944538

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = Max(ase1,ase2) = 0.24250288

bo_2 = 192.00

ho_2 = 192.00

$$bi2_2 = 147456.00$$
$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.00633$$

$$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.00633$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 400.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 200.00$$

$$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.00633$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 400.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/l_d = 1.00$$

$$su1 = 0.4*esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25*(lb/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/l_b,min = 1.00$$

$$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25*(lb/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

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 = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444

with Esv = (Esjacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 454364.743

Calculation of Shear Strength at edge 1, Vr1 = 454364.743

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 454364.743

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 = 29.75, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.4805782E-012

Vu = 1.5450773E-031

d = 0.8*h = 320.00

Nu = 5976.808

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279252.68

where:

Vs1 = 279252.68 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 463788.751
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 454364.743

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 454364.743

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 = 29.75, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.4805782E-012

Vu = 1.5450773E-031

d = 0.8*h = 320.00

Nu = 5976.808

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279252.68

where:

Vs1 = 279252.68 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 463788.751

bw = 400.00

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, $\phi = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($b/d > 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -3.2971707E-011$

Shear Force, $V_2 = 5671.441$

Shear Force, $V_3 = -3.0815100E-014$

Axial Force, $F = -5974.539$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{c,com} = 1137.257$

-Middle: $As_{mid} = 402.1239$

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: $As_{t,ten,core} = 307.8761$

-Compression: $As_{c,com,core} = 307.8761$

-Middle: $As_{mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \phi * u = 0.03951044$

$u = y + p = 0.03951044$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00632045$ ((4.29), Biskinis Phd))

$M_y = 2.1541E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength: $f_c' = (f_{c'}^{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_{c'}^{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 29.75$

$N = 5974.539$

$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 5.6801\text{E}+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$

$y_{\text{ten}} = 1.0313992\text{E}-005$

with $f_y = 529.9948$

$d = 357.00$

$y = 0.28030815$

$A = 0.0188229$

$B = 0.01057976$

with $p_t = 0.00442965$

$p_c = 0.00796398$

$p_v = 0.00281599$

$N = 5974.539$

$b = 400.00$

$\mu = 0.12044818$

$y_{\text{comp}} = 2.2027043\text{E}-005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.27977391$

$A = 0.01864887$

$B = 0.01050082$

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: $p = 0.03319$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/d \geq 1$

shear control ratio $V_y E / V_{CoI} O E = 0.48493697$

$d = d_{\text{external}} = 357.00$

$s = s_{\text{external}} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$

jacket: $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 400.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 200.00$

$s_2 = 250.00$

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.

$N_{UD} = 5974.539$

$A_g = 160000.00$

$f_{cE} = (f_{c'}^{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_{c'}^{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 29.75$

$f_{yE} = (f_{y_{\text{ext_Long_Reinf}}} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_{y_{\text{int_Long_Reinf}}} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 529.9948$

$f_{yE} = (f_{y_{\text{ext_Trans_Reinf}}} \cdot \text{Area}_{\text{ext_Trans_Reinf}} + f_{y_{\text{int_Trans_Reinf}}} \cdot \text{Area}_{\text{int_Trans_Reinf}}) / \text{Area}_{\text{Tot_Trans_Rein}} = 542.9472$

$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01874396$

$b = 400.00$

d = 357.00
f_{cE} = 29.75

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

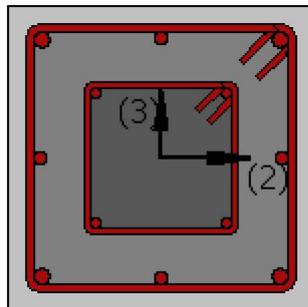
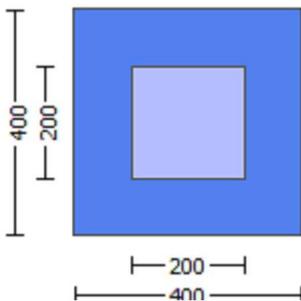
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -5.9427557E-011$

Shear Force, $V_a = 3.0815100E-014$

EDGE -B-

Bending Moment, $M_b = -3.2971707E-011$

Shear Force, $V_b = -3.0815100E-014$

BOTH EDGES

Axial Force, $F = -5974.539$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 0.00$

-Compression: $A_{slc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1137.257$

-Compression: $A_{sl,com} = 1137.257$

-Middle: $A_{sl,mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 404606.974$

V_n ((10.3), ASCE 41-17) = $k_n l V_{CoI} = 404606.974$

$V_{CoI} = 404606.974$

$k_n l = 1.00$

$displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + \phi V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

 $\phi = 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 22.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 3.2971707E-011$

$V_u = 3.0815100E-014$

$d = 0.8 \cdot h = 320.00$

$N_u = 5974.539$

$A_g = 160000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$
 where:
 $V_{s1} = 251327.412$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.3125$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 405571.497$
 $bw = 400.00$

 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 = $5.0944900E-023$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00632045$ ((4.29), Biskinis Phd)
 $M_y = 2.1541E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7040E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$
 $N = 5974.539$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.6801E+013$

 Calculation of Yielding Moment M_y

 Calculation of ϕ and M_y according to Annex 7 -

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0313992E-005$
 with $f_y = 529.9948$
 $d = 357.00$
 $y = 0.28030815$
 $A = 0.0188229$
 $B = 0.01057976$
 with $pt = 0.00796398$
 $pc = 0.00796398$
 $pv = 0.00281599$
 $N = 5974.539$
 $b = 400.00$
 $\rho = 0.12044818$
 $y_{comp} = 2.2027043E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.27977391$
 $A = 0.01864887$
 $B = 0.01050082$
 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: (b)

Calculation No. 16

column C1, Floor 1

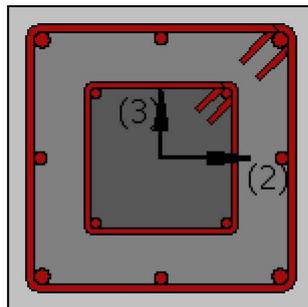
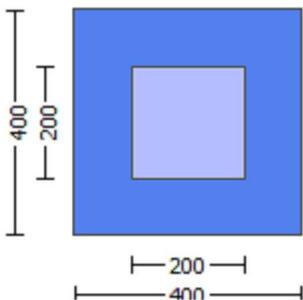
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03496

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.8733604E-032$

EDGE -B-

Shear Force, $V_b = -3.8733604E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, \text{ten}} = 1137.257$

-Compression: $A_{st, \text{com}} = 1137.257$

-Middle: $A_{st, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$

with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3051E+008$
 $M_{u1+} = 3.3051E+008$, 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

$M_{u1-} = 3.3051E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3051E+008$

$M_{u2+} = 3.3051E+008$, 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

$M_{u2-} = 3.3051E+008$, 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:

$\phi_u = 0.00010695$

$M_u = 3.3051E+008$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{o, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1, \text{nominal}} = 0.08,$$

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.

$$\text{with } fs_1 = (fs_{\text{jacket}} * A_{sl, \text{jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 656.8447$$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 788.2136$
 $fy_2 = 656.8447$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{ou,min} = lb/lb_{,min} = 1.00$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2 / 1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 656.8447$
 with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $fy_v = 694.4444$
 $suv = 0.032$
 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
 $lo/lo_{ou,min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_v = fs_v / 1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_v = fs_v / 1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15851815$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15851815$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05925912$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.20360129$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.20360129$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.07611263$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16187171$
 $Mu = MRc (4.14) = 3.3051E+008$
 $u = su (4.1) = 0.00010695$

 Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00944538$$

$$w_e(5.4c) = 0.02209223$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1, \text{nominal}} = 0.08,$$

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 656.8447$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 788.2136$

$fy_2 = 656.8447$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{d,min} = 1.00$

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 656.8447$

with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$su_v = 0.032$

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

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_v = 0.4 \cdot esu_{v,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{v,nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 694.4444$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15851815$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15851815$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05925912$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.15357$

$cc (5A.5, TBDY) = 0.00234957$

$c = \text{confinement factor} = 1.03496$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.20360129$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.20360129$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.16187171$

$Mu = MRc (4.14) = 3.3051E+008$

$u = su (4.1) = 0.00010695$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_{2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010695$$

$$\mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00944538$$

$$\phi_{we}(5.4c) = 0.02209223$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou, \min} = l_b / d = 1.00$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 656.8447$$

$$\text{with } Es1 = (Es_jacket * Asl,ten,jacket + Es_core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 656.8447$$

$$\text{with } Es2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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.

yv, shv, ftv, fyv , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 694.4444$$

$$\text{with } Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15851815$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15851815$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05925912$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.15357$$

$$cc (5A.5, TBDY) = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.20360129$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.20360129$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07611263$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16187171$$

$$Mu = MRc (4.14) = 3.3051E+008$$

$$u = su (4.1) = 0.00010695$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu2-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00010695$$

$$Mu = 3.3051E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00944538$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00944538$$

$$w_e \text{ (5.4c)} = 0.02209223$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.00633$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

No stirrups, $n_{s_1} = 2.00$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

No stirrups, $n_{s_2} = 2.00$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.00633$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

No stirrups, $n_{s_1} = 2.00$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

No stirrups, $n_{s_2} = 2.00$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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 = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

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 = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

Calculation of ratio lb/ld

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 454364.743$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0401148E-011$

$V_u = 3.8733604E-032$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.5625$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 463788.751$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 454364.743$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0401148E-011$

$V_u = 3.8733604E-032$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$

where:

$V_{s1} = 279252.68$ is calculated for jacket, with:

$d = 320.00$

Av = 157079.633
fy = 555.5556
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 463788.751
bw = 400.00

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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
#####

External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03496
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lo_u,min >= 1)
No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -1.5450773E-031$

EDGE -B-

Shear Force, $V_b = 1.5450773E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1137.257$

-Compression: $A_{sc,com} = 1137.257$

-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.48493697$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 220338.264$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3051E+008$

$M_{u1+} = 3.3051E+008$, 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

$M_{u1-} = 3.3051E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3051E+008$

$M_{u2+} = 3.3051E+008$, 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

$M_{u2-} = 3.3051E+008$, 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:

$\phi_u = 0.00010695$

$M_u = 3.3051E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00944538$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_c = 0.00944538$

ϕ_w (5.4c) = 0.02209223

ϕ_{ase} ((5.4d), TBDY) = $(\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.24250288$

$\phi_{ase1} = 0.24250288$

$\phi_{bo_1} = 340.00$

$\phi_{ho_1} = 340.00$

$\phi_{bi2_1} = 462400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$

$\phi_{bo_2} = 192.00$

$\phi_{ho_2} = 192.00$

$\phi_{bi2_2} = 147456.00$

$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 3.00633$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008
ft1 = 788.2136
fy1 = 656.8447
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 788.2136
fy2 = 656.8447
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.3333
fyv = 694.4444
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

svv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.

with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

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 = 0.00010695

Mu = 3.3051E+008

with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.00126831

N = 5976.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00944538

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00944538

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = Max(ase1,ase2) = 0.24250288

bo_2 = 192.00

ho_2 = 192.00

$$bi2_2 = 147456.00$$
$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.00633$$

$$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.00633$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 400.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 200.00$$

$$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.00633$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 400.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00234957$$

$$c = \text{confinement factor} = 1.03496$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/l_d = 1.00$$

$$su1 = 0.4*esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/l_b,min = 1.00$$

$$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

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 = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815

2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815

v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.15357

cc (5A.5, TBDY) = 0.00234957

c = confinement factor = 1.03496

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129

2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129

v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16187171

Mu = MRc (4.14) = 3.3051E+008

u = su (4.1) = 0.00010695

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 = 0.00010695

Mu = 3.3051E+008

with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.00126831

N = 5976.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00944538

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00944538

we (5.4c) = 0.02209223

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

bi2_1 = 462400.00

ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008
ft1 = 788.2136
fy1 = 656.8447
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 788.2136
fy2 = 656.8447
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_b,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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 = 656.8447

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

$shv = 0.008$
 $ftv = 833.3333$
 $fyv = 694.4444$
 $suv = 0.032$
 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 $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$
 with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.15851815$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.15851815$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05925912$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.20360129$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.20360129$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.07611263$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16187171$
 $Mu = MRc (4.14) = 3.3051E+008$
 $u = su (4.1) = 0.00010695$

 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:

$u = 0.00010695$
 $Mu = 3.3051E+008$

 with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00944538$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00944538$
 $we (5.4c) = 0.02209223$
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288$
 $ase1 = 0.24250288$

bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.00633

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.00633
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00234957
c = confinement factor = 1.03496

y1 = 0.0025
sh1 = 0.008
ft1 = 788.2136
fy1 = 656.8447
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 788.2136
fy2 = 656.8447
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.

$\text{with } fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 656.8447$
 $\text{with } Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.3333$
 $fyv = 694.4444$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou_{min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 $\text{with } fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.4444$
 $\text{with } Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15851815$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15851815$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925912$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.15357$
 $cc (5A.5, TBDY) = 0.00234957$
 $c = \text{confinement factor} = 1.03496$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.20360129$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.20360129$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611263$

Case/Assumption: Unconfined full section - Steel rupture

'satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$su (4.9) = 0.16187171$
 $\mu = MRc (4.14) = 3.3051E+008$
 $u = su (4.1) = 0.00010695$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 454364.743$

Calculation of Shear Strength at edge 1, $V_{r1} = 454364.743$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{ColO}$

$V_{ColO} = 454364.743$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 29.75$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu = 2.4805782E-012$

$V_u = 1.5450773E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

Ag = 160000.00
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$
where:
 $V_{s1} = 279252.68$ is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 555.5556
s = 100.00
 V_{s1} is multiplied by Col1 = 1.00
s/d = 0.3125
 $V_{s2} = 0.00$ is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00
 V_{s2} is multiplied by Col2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
bw = 400.00

Calculation of Shear Strength at edge 2, $V_{r2} = 454364.743$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = knl* V_{Col0}
 $V_{Col0} = 454364.743$
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 Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 29.75$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 2.4805782E-012
Vu = 1.5450773E-031
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 279252.68$
where:
 $V_{s1} = 279252.68$ is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 555.5556
s = 100.00
 V_{s1} is multiplied by Col1 = 1.00
s/d = 0.3125
 $V_{s2} = 0.00$ is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 444.4444
s = 250.00
 V_{s2} is multiplied by Col2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 463788.751$
bw = 400.00

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, $\gamma = 1.00$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 400.00$
External Width, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d >= 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -0.00436447$
Shear Force, $V_2 = 5671.441$
Shear Force, $V_3 = -3.0815100E-014$
Axial Force, $F = -5974.539$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl} = 0.00$
-Compression: $A_{slc} = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1137.257$
-Compression: $A_{sl,com} = 1137.257$
-Middle: $A_{sl,mid} = 402.1239$
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: $A_{sl,ten,core} = 307.8761$
-Compression: $A_{sl,com,core} = 307.8761$
-Middle: $A_{sl,mid,core} = 0.00$
Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \gamma * u = 0.03445409$
 $u = \gamma + \rho = 0.03445409$

- Calculation of γ -

$$y = (M_y * L_s / 3) / E_{eff} = 0.00126409 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 2.1541E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 300.00$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.7040E+013$$

$$\text{factor} = 0.30$$

$$A_g = 160000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 29.75$$

$$N = 5974.539$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 5.6801E+013$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 1.0313992E-005$$

$$\text{with } f_y = 529.9948$$

$$d = 357.00$$

$$y = 0.28030815$$

$$A = 0.0188229$$

$$B = 0.01057976$$

$$\text{with } p_t = 0.00442965$$

$$p_c = 0.00796398$$

$$p_v = 0.00281599$$

$$N = 5974.539$$

$$b = 400.00$$

$$" = 0.12044818$$

$$y_{\text{comp}} = 2.2027043E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.27977391$$

$$A = 0.01864887$$

$$B = 0.01050082$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.03319$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/d \geq 1$

$$\text{shear control ratio } V_y E / V_{CoI} E = 0.48493697$$

$$d = d_{\text{external}} = 357.00$$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00392699$$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00050265$$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 200.00$$

$$s_2 = 250.00$$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$N_{UD} = 5974.539$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c_{\text{jacket}}} * A_{\text{jacket}} + f_{c_{\text{core}}} * A_{\text{core}}) / \text{section_area} = 29.75$$

$f_{yE} = (f_{y_ext_Long_Reinf} * Area_ext_Long_Reinf + f_{y_int_Long_Reinf} * Area_int_Long_Reinf) / Area_Tot_Long_Rein = 529.9948$
 $f_{yE} = (f_{y_ext_Trans_Reinf} * Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} * Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 542.9472$
 $\rho_l = Area_Tot_Long_Rein / (b * d) = 0.01874396$
 $b = 400.00$
 $d = 357.00$
 $f_{cE} = 29.75$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)