

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

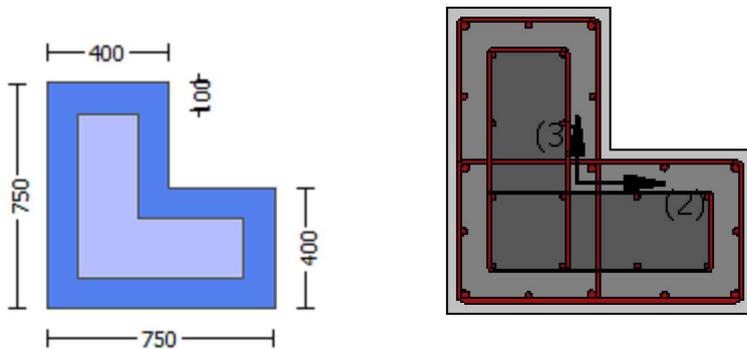
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjlc

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

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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, $f_s = f_{sm} = 444.4444$

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Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -2.3735E+007$

Shear Force, $V_a = -7874.616$

EDGE -B-

Bending Moment, $M_b = 105242.575$

Shear Force, $V_b = 7874.616$

BOTH EDGES

Axial Force, $F = -17081.857$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{st,com} = 2362.478$

-Middle: $A_{st,mid} = 2469.292$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 876340.192$

V_n ((10.3), ASCE 41-17) = $k_n \phi V_{Col} = 876340.192$

$V_{Col} = 876340.192$

$k_n = 1.00$

displacement_ductility_demand = 0.03712301

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

8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 2.3735E+007$$

$$V_u = 7874.616$$

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

$$N_u = 17081.857$$

$$A_g = 300000.00$$

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

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$$

$V_{s,j1} = 251327.412$ is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

$V_{s,j2} = 471238.898$ is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

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

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

$$s/d = 1.5625$$

$V_{s,c2} = 70773.799$ is calculated for section flange core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

$$s/d = 0.56818182$$

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

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

$$bw = 400.00$$

displacement_ductility_demand is calculated as ϕ / y

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

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

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

$$M_y = 3.6949E+008$$

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

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

$$\text{factor} = 0.30$$

$$A_g = 440000.00$$

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

$$N = 17081.857$$

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

Calculation of Yielding Moment M_y

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

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$

web width, $b_w = 400.00$

flange thickness, $t = 400.00$

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

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

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

$d = 707.00$

$y = 0.20059112$

$A = 0.01136735$

$B = 0.00499612$

with $pt = 0.00214476$

$pc = 0.0044554$

$pv = 0.00465684$

$N = 17081.857$

$b = 750.00$

$" = 0.06082037$

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

with $fc = 33.00$

$E_c = 26999.444$

$y = 0.19866301$

$A = 0.01118379$

$B = 0.00488577$

with $E_s = 200000.00$

CONFIRMATION: $y = 0.19957893 < t/d$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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

At local axis: 2

Integration Section: (a)

Calculation No. 2

column C1, Floor 1

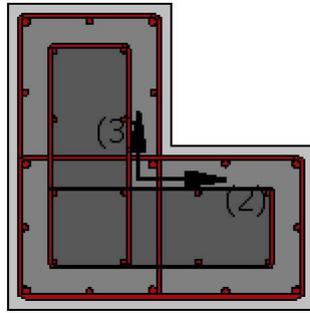
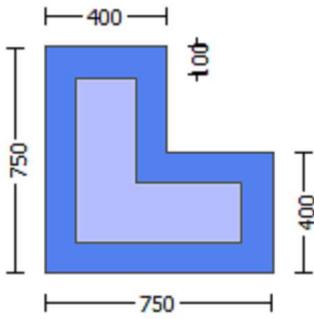
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$

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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, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -0.0005439$

EDGE -B-

Shear Force, $V_b = 0.0005439$

BOTH EDGES

Axial Force, $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

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

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

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

with

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

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

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

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

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

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

Calculation of Mu_{1+}

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

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

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

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

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

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

$\omega_e (5.4c) = 0.01216945$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

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

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

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

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

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

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

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

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

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

with $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

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

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

$su2 = 0.4 * esu2_{nominal}$ ((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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$

with $Es2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

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

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

lo/lou,min = lb/ld = 0.30

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

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

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

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

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

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

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.14856848

Mu = MRc (4.14) = 5.0139E+008

u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00174912

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00791261

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

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1) * (Aconf,min1/Aconf,max1), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

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

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 368.7326$$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2/1.2$, 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 $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 367.9484$
 with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 431.8911$
 $fy_v = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_d = 0.30$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_v = fs_v/1.2$, 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 $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 359.9093$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.093334389$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483859$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.09522963$

and confined core properties:

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$su (4.9) = 0.22227278$
 $M_u = MR_c (4.14) = 8.4307E+008$
 $u = su (4.1) = 9.3115772E-006$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of M_{u2+}

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

$$\mu = 8.5055191E-006$$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

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

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

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

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

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{psh}_{min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 2.92621$$

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

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.92621$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\text{psh}_2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.92621$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\text{psh}_2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.538$$

$$fy1 = 367.9484$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 367.9484$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 442.4791$$

$$fy2 = 368.7326$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 368.7326$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 431.8911$$

$$fyv = 359.9093$$

$$suv = 0.00512$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 359.9093$$

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

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

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

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

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.02714524$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.05651029$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.14856848$$

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

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

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

$$u = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

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

$$w_e(5.4c) = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

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

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

Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.92621
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00367709
Lstir₁ (Length of stirrups along X) = 2060.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00067082
Lstir₂ (Length of stirrups along X) = 1468.00
Astir₂ (stirrups area) = 50.26548

Asec = 440000.00
s₁ = 100.00
s₂ = 250.00

fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

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

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

lo/lou,min = lb/l_d = 0.30

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} = 368.7326

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

y₂ = 0.00140044
sh₂ = 0.0044814

ft₂ = 441.538
fy₂ = 367.9484

su₂ = 0.00512

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

lo/lou,min = lb/l_{b,min} = 0.30

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.

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} = 367.9484

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

y_v = 0.00140044
sh_v = 0.0044814

ft_v = 431.8911
fy_v = 359.9093

suv = 0.00512

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

lo/lou,min = lb/l_d = 0.30

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

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

considering characteristic value 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} = 359.9093

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

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

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483859$$

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

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22227278$$

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

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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

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

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

$$V_{Col0} = 998297.143$$

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

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

$$M/Vd = 4.00$$

$$M_u = 326.4029$$

$$V_u = 0.0005439$$

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

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$

$$s/d = 1.5625$$

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

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$$bw = 400.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$

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

$$V_{Col0} = 998297.143$$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 326.4024$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

V_{s,c2} is multiplied by Col,c2 = 0.00
s/d = 1.5625
V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: V_s + V_f <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjls

Constant Properties

Knowledge Factor, γ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

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

Jacket
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$
#####

Max Height, H_{max} = 750.00
Min Height, H_{min} = 400.00
Max Width, W_{max} = 750.00
Min Width, W_{min} = 400.00
Jacket Thickness, t_j = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with l_o/l_{o,u,min} = 0.30
No FRP Wrapping

Stepwise Properties

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

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sc,com} = 2362.478$

-Middle: $A_{st,mid} = 2469.292$

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

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

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

with

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

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

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

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

$M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

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

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

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

w_e (5.4c) = 0.01216945

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

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

c = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

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

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

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

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

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

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

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

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

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

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

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

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

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

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$$f_{tv} = 431.8911$$

$$f_{yv} = 359.9093$$

$$s_{uv} = 0.00512$$

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

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

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

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

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

For calculation of $e_{suv,nominal}$ and γ_v , sh_v, f_{tv}, f_{yv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

$\gamma_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 359.9093$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.02391392$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04978341$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

c = confinement factor = 1.00

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.02714524$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05651029$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.14856848$$

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

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$$u = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

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

$$w_e (5.4c) = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

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

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

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered

characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

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

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

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

$y2 = 0.00140044$

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

 Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Mu_{2+}

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

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

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

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

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

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

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

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$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

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

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

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

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

lo/lou,min = lb/ld = 0.30

su1 = 0.4*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 = 367.9484

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

y2 = 0.00140044
sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

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

yv = 0.00140044
shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

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

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

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

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

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

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

---->

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

---->

$$\begin{aligned} su(4.9) &= 0.14856848 \\ \mu &= MRc(4.14) = 5.0139E+008 \\ u &= su(4.1) = 8.5055191E-006 \end{aligned}$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_2

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

$$\begin{aligned} u &= 9.3115772E-006 \\ \mu &= 8.4307E+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 400.00 \\ d &= 707.00 \\ d' &= 43.00 \\ v &= 0.00174912 \\ N &= 16323.501 \end{aligned}$$

$$\begin{aligned} f_c &= 33.00 \\ c_o(5A.5, TBDY) &= 0.002 \\ \text{Final value of } c_u: c_u^* &= \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261 \end{aligned}$$

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

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

$$w_e(5.4c) = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

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

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

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

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

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.92621
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00367709
Lstir₁ (Length of stirrups along X) = 2060.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00067082
Lstir₂ (Length of stirrups along X) = 1468.00
Astir₂ (stirrups area) = 50.26548

Asec = 440000.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.4444

fywe₂ = 555.5556

fce = 33.00

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

c = confinement factor = 1.00

y₁ = 0.00140044

sh₁ = 0.0044814

ft₁ = 442.4791

fy₁ = 368.7326

su₁ = 0.00512

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

lo/lou,min = lb/ld = 0.30

su₁ = 0.4*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 = 368.7326

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

y₂ = 0.00140044

sh₂ = 0.0044814

ft₂ = 441.538

fy₂ = 367.9484

su₂ = 0.00512

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

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

su₂ = 0.4*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 = 367.9484

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

y_v = 0.00140044

sh_v = 0.0044814

ft_v = 431.8911

fy_v = 359.9093

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

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

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

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

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

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22227278$$

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

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

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

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

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

$$V_{Col0} = 998297.143$$

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

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

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

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

$$M/Vd = 4.00$$

$$\mu_u = 326.5735$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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

where:

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

$V_{sj1} = 279252.68$ is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$$s/d = 0.3125$$

$V_{sj2} = 523598.776$ is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$$s/d = 0.16666667$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_r2 = 998297.143$
 $V_r2 = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l * V_{ColO}$
 $V_{ColO} = 998297.143$
 $k_n l = 1$ (zero step-static loading)

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

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

$M/d = 4.00$
 $M_u = 326.5741$
 $V_u = 0.0005439$
 $d = 0.8 * h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$

Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -233750.983
Shear Force, V2 = -7874.616
Shear Force, V3 = 112.3724
Axial Force, F = -17081.857
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Asl,t = 0.00
-Compression: Asl,c = 5969.026
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2362.478
-Middle: Asl,mid = 2469.292
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761

-Compression: $A_{sl,com,core} = 615.7522$

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

Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = u = 0.00176802$
 $u = y + p = 0.00176802$

- Calculation of y -

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

$M_y = 3.6949E+008$

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

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

factor = 0.30

$A_g = 440000.00$

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

$N = 17081.857$

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

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$

web width, $b_w = 400.00$

flange thickness, $t = 400.00$

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

$y_{ten} = 2.5827649E-006$

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

$d = 707.00$

$y = 0.20059112$

$A = 0.01136735$

$B = 0.00499612$

with $pt = 0.00434791$

$pc = 0.0044554$

$pv = 0.00465684$

$N = 17081.857$

$b = 750.00$

" = 0.06082037

$y_{comp} = 1.5663730E-005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866301$

$A = 0.01118379$

$B = 0.00488577$

with $E_s = 200000.00$

CONFIRMATION: $y = 0.19957893 < t/d$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_{yE}/V_{CoIE} = 0.56300412$

$d = d_{\text{external}} = 707.00$

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

- $t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00434791$

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

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

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

$s_1 = 100.00$

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

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

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

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

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

For the normalisation f_s of jacket is used.

$NUD = 17081.857$

$A_g = 440000.00$

$f_{cE} = (f_{c_jacket} \cdot \text{Area_jacket} + f_{c_core} \cdot \text{Area_core}) / \text{section_area} = 27.68182$

$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot \text{Area_ext_Long_Reinf} + f_{y_int_Long_Reinf} \cdot \text{Area_int_Long_Reinf}) / \text{Area_Tot_Long_Rein} = 521.1696$

$f_{yIE} = (f_{y_ext_Trans_Reinf} \cdot s_1 + f_{y_int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$

$\rho_l = \text{Area_Tot_Long_Rein} / (b \cdot d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

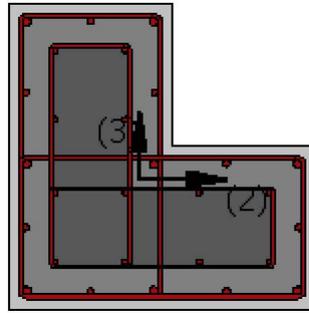
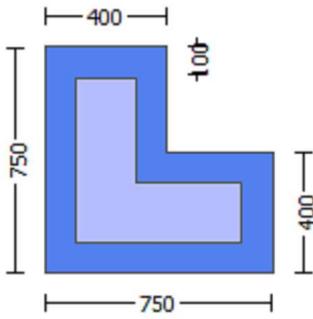
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 444.4444$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -233750.983$

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

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 897900.016$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI0} = 897900.016$
 $V_{CoI} = 897900.016$
 $k_n = 1.00$
displacement_ductility_demand = 0.02111012

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

= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 21.31818$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/d = 3.46691$
 $M_u = 233750.983$
 $V_u = 112.3724$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 17081.857$
 $A_g = 300000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 793340.11$
where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$
 $V_{s,j1} = 471238.898$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 251327.412$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 70773.799$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$

s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 736127.561
bw = 400.00

displacement_ductility_demand is calculated as / y

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

From analysis, chord rotation = 3.7323117E-005
y = (My*Ls/3)/Eleff = 0.00176802 ((4.29),Biskinis Phd))
My = 3.6949E+008
Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 2080.146
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17081.857
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+014

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

y = Min(y_ten, y_com)
y_ten = 2.5827649E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/d)^ 2/3) = 291.9465
d = 707.00
y = 0.20059112
A = 0.01136735
B = 0.00499612
with pt = 0.00214476
pc = 0.0044554
pv = 0.00465684
N = 17081.857
b = 750.00
" = 0.06082037
y_comp = 1.5663730E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866301
A = 0.01118379
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19957893 < t/d

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

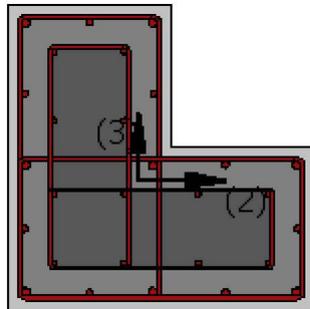
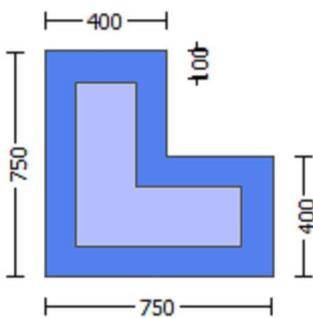
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjlc

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

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

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

Calculation of μ_{u1+}

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

with full section properties:

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

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

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

$$w_e \text{ (5.4c)} = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

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

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.538$$

$$fy1 = 367.9484$$

$$su1 = 0.00512$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

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

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

$$\text{with } fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 442.4791$$

$$fy_2 = 368.7326$$

$$su_2 = 0.00512$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.30$$

$$su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$$

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

For calculation of $esu_{2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$suv = 0.00512$$

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

$$lo/lou, \text{min} = lb/ld = 0.30$$

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$$

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

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.02391392$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.04978341$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.02714524$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.05651029$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.14856848$$

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

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

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu1-

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

$$\mu = 9.3115772E-006$$

$$\mu = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

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

$$w_e \text{ (5.4c)} = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Asec = 440000.00
 s1 = 100.00
 s2 = 250.00
 fywe1 = 694.4444
 fywe2 = 555.5556
 fce = 33.00
 From ((5.A.5), TBDY), TBDY: cc = 0.002
 c = confinement factor = 1.00
 y1 = 0.00140044
 sh1 = 0.0044814
 ft1 = 442.4791
 fy1 = 368.7326
 su1 = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 lo/lou,min = lb/lb = 0.30
 su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: esu1_nominal = 0.08,
 For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
 characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
 y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326
 with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
 y2 = 0.00140044
 sh2 = 0.0044814
 ft2 = 441.538
 fy2 = 367.9484
 su2 = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 lo/lou,min = lb/lb,min = 0.30
 su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: esu2_nominal = 0.08,
 For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
 characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
 y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484
 with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
 yv = 0.00140044
 shv = 0.0044814
 ftv = 431.8911
 fyv = 359.9093
 suv = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 lo/lou,min = lb/lb = 0.30
 suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: esuv_nominal = 0.08,
 considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
 For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
 characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
 y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093
 with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
 1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
 2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
 v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
 and confined core properties:
 b = 340.00
 d = 677.00
 d' = 13.00
 fcc (5A.2, TBDY) = 33.00
 cc (5A.5, TBDY) = 0.002
 c = confinement factor = 1.00

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

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

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

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

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

$$\text{su (4.9)} = 0.22227278$$

$$\text{Mu} = \text{MRc (4.14)} = 8.4307\text{E}+008$$

$$u = \text{su (4.1)} = 9.3115772\text{E}-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

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

$$u = 8.5055191\text{E}-006$$

$$\text{Mu} = 5.0139\text{E}+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.00791261$

$$w_e \text{ (5.4c)} = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

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

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

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

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

lo/lou,min = lb/ld = 0.30

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484

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

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

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

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

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

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

lo/lou,min = lb/ld = 0.30

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

From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

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

with $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$

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

1 = $A_{sl,ten} / (b * d) * (fs1 / fc) = 0.02391392$

2 = $A_{sl,com} / (b * d) * (fs2 / fc) = 0.04978341$

v = $A_{sl,mid} / (b * d) * (fsv / fc) = 0.05078914$

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $A_{sl,ten} / (b * d) * (fs1 / fc) = 0.02714524$

2 = $A_{sl,com} / (b * d) * (fs2 / fc) = 0.05651029$

v = $A_{sl,mid} / (b * d) * (fsv / fc) = 0.05765191$

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

---->

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

---->

su (4.9) = 0.14856848

Mu = MRc (4.14) = 5.0139E+008

u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 0.30

Calculation of Mu2-

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

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00174912

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = shear_factor * Max(cu, cc) = 0.00791261$

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

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

we (5.4c) = 0.01216945

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
ase2 (\geq ase1) = $\text{Max}(((A_{\text{conf,max2}} - \text{AnoConf2}) / A_{\text{conf,max2}}) * (A_{\text{conf,min2}} / A_{\text{conf,max2}}), 0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

psh,min*Fywe = $\text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.92621$

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

psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.92621

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

Lstir1 (Length of stirrups along Y) = 2060.00

Astir1 (stirrups area) = 78.53982

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

Lstir2 (Length of stirrups along Y) = 1468.00

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.92621

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

Lstir1 (Length of stirrups along X) = 2060.00

Astir1 (stirrups area) = 78.53982

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

Lstir2 (Length of stirrups along X) = 1468.00

Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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

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

with fs1 = $(f_{s,\text{jacket}} * A_{s1,\text{ten,jacket}} + f_{s,\text{core}} * A_{s1,\text{ten,core}}) / A_{s1,\text{ten}} = 368.7326$

with Es1 = $(E_{s,\text{jacket}} * A_{s1,\text{ten,jacket}} + E_{s,\text{core}} * A_{s1,\text{ten,core}}) / A_{s1,\text{ten}} = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

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

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

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

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.

$$\text{with } fs_2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 367.9484$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 431.8911$$

$$fyv = 359.9093$$

$$suv = 0.00512$$

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

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

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

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

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

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

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.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 359.9093$$

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

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.09334389$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.04483859$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.11468265$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.05508886$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.22227278$$

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

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

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

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

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

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

$$V_{Col0} = 998297.143$$

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

NOTE: In expression (10-3) ' $V_s = A_v * fy * d / s$ ' 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: $fc' = (fc'_jacket * Area_jacket + fc'_core * Area_core) / Area_section = 27.68182$, but $fc'^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$
 $\mu_u = 326.4029$
 $\nu_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $b_w = 400.00$

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

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

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

$M/Vd = 4.00$
 $\mu_u = 326.4024$
 $\nu_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$

$s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcjlc

Constant Properties

 Knowledge Factor, $= 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
 Existing Column
 Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

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

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

Calculation of M_{u1+}

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

with full section properties:

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

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

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

w_e (5.4c) = 0.01216945

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

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

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

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

A_{stir1} (stirrups area) = 78.53982

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

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

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

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

c = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

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

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

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

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

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

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

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

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

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

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

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

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

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

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

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

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 431.8911$

$fyv = 359.9093$

$suv = 0.00512$

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

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

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

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

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

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

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

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

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$

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

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

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

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

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.14856848$

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

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

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu1-

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

$$\mu = 9.3115772E-006$$

$$Mu = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

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

$$w_e (5.4c) = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$s_2 = 250.00$
 $fy_{we1} = 694.4444$
 $fy_{we2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00140044$
 $sh_1 = 0.0044814$
 $ft_1 = 442.4791$
 $fy_1 = 368.7326$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$
 with $Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9484$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 431.8911$
 $fy_v = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.09334389$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.04483859$
 $v = A_{sl,mid} / (b * d) * (fs_v / f_c) = 0.09522963$
 and confined core properties:
 $b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.11468265$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.05508886$

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

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

--->

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

--->

$$s_u(4.9) = 0.22227278$$

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

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2+}

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

$$u = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

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

$$w_e(5.4c) = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf, min}$ and $A_{conf, max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf, max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf, min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf, max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf, min}$ and $A_{conf, max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf, max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf, min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf, max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

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

psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

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

lo/lou,min = lb/d = 0.30

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

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

with fs1 = $(f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9484$

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

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

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

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

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

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

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

with fs2 = $(f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 368.7326$

with Es2 = $(E_{s,jacket} * A_{s,com,jacket} + E_{s,core} * A_{s,com,core}) / A_{s,com} = 200000.00$

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/d = 0.30

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

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

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

For calculation of $e_{suv_nominal}$ and γ_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 359.9093$

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02391392$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04978341$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

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

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02714524$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05651029$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.14856848

$\mu_u = MR_c$ (4.14) = 5.0139E+008

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

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

$u = 9.3115772E-006$

$\mu_u = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174912$

$N = 16323.501$

$f_c = 33.00$

cc (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.00791261$

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

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

w_e (5.4c) = 0.01216945

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

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

c = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 368.7326$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

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

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

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

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

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

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

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

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 431.8911$

$fy_v = 359.9093$

$suv = 0.00512$

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

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

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

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = f_{sv}/1.2$, 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 $fs_{yv} = f_{sv}/1.2$, 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 $f_{sv} = (f_{s,jacket} \cdot Asl_{mid,jacket} + f_{s,mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

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

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

$2 = Asl_{com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483859$

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

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

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

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.22227278$

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

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

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

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

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

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

$V_{ColO} = 998297.143$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 4.00$

$Mu = 326.5735$

$V_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

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

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

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $M_u = 326.5741$
 $V_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

s/d = 0.3125

$V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:

d = 600.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 100.00

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

s/d = 0.16666667

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

d = 160.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

s/d = 1.5625

$V_{s,c2} = 78637.555$ is calculated for section flange core, with:

d = 440.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

s/d = 0.56818182

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

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjlc

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

Stepwise Properties

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

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.00256184$
 $u = y + p = 0.00256184$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00256184$ ((4.29), Biskinis Phd))
 $M_y = 3.6949E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3014.102
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$
factor = 0.30
 $A_g = 440000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$
 $N = 17081.857$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

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

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

 Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

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

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

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

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

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

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

$s_1 = 100.00$

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

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

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

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

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

For the normalisation f_s of jacket is used.

$N_{UD} = 17081.857$

$A_g = 440000.00$

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

$f_{yI} E = (f_{y,ext_Long_Reinf} * Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} * Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 521.1696$

$f_{yT} E = (f_{y,ext_Trans_Reinf} * s_1 + f_{y,int_Trans_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$p_l = Area_{Tot_Long_Rein} / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

 End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

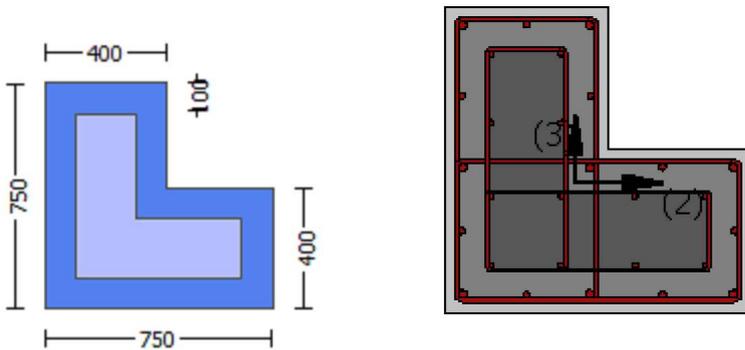
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 444.4444$

#####

Max Height, Hmax = 750.00
Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

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

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

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

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 21.31818$, but $f_c'^{0.5} <=$
8.3 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 105242.575$
 $V_u = 7874.616$
 $d = 0.8 * h = 600.00$
 $N_u = 17081.857$
 $A_g = 300000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 793340.11$
where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$
 $V_{s,j1} = 251327.412$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 471238.898$ is calculated for section flange jacket, with:

$d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 70773.799$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 736127.561$
 $b_w = 400.00$

 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 $\theta = 2.4784478E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00025498$ ((4.29), Biskinis Phd)
 $M_y = 3.6949E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$
 $factor = 0.30$
 $A_g = 440000.00$
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$
 $N = 17081.857$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

 Calculation of Yielding Moment M_y

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

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

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

y_comp = 1.5663730E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866301
A = 0.01118379
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19957893 < t/d

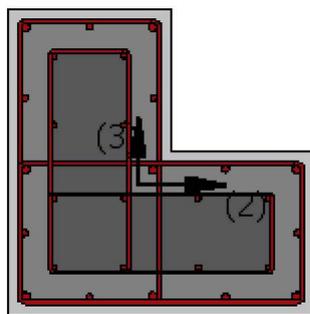
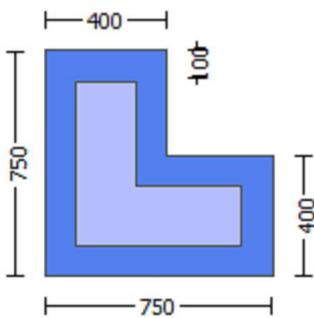
Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 0.30

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Chord rotation capacity (u)
Edge: End
Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlc

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -0.0005439$

EDGE -B-

Shear Force, $V_b = 0.0005439$

BOTH EDGES

Axial Force, $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com} = 2362.478$

-Middle: $A_{sl,mid} = 2469.292$

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

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

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

with

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

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

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

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

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

which is defined for the the static loading combination

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

Calculation of μ_{u1+}

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

$$\mu = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

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

$$w_e \text{ (5.4c)} = 0.01216945$$

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

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

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

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

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

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

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00140044
sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

svv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$$su (4.9) = 0.14856848$$

$$Mu = MRc (4.14) = 5.0139E+008$$

$$u = su (4.1) = 8.5055191E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$Mu = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 2.92621$$

Expression (5.4d) for $psh_{min} * Fy_{we}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/ld = 0.30$$

$$su1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 368.7326$$

$$\text{with } Es1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/lb_{min} = 0.30$$

$$su2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9484$$

$$\text{with } Es2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$su_v = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389

2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859

v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265

2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886

v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.22227278

Mu = MRc (4.14) = 8.4307E+008

u = su (4.1) = 9.3115772E-006

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.5055191E-006

Mu = 5.0139E+008

with full section properties:

b = 750.00

d = 707.00

d' = 43.00

v = 0.00093286

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00791261

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase_2 (>= ase_1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_0/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with $Es_1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14856848

Mu = MRc (4.14) = 5.0139E+008

u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (> a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along } X) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along } X) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

$$s_u1 = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su1,nominal} = 0.08$,

For calculation of $e_{su1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 368.7326$$

$$\text{with } E_{s1} = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.538$$

$$fy_2 = 367.9484$$

$$s_u2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 367.9484$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s,com,jacket} + E_{s,core} * A_{s,com,core}) / A_{s,com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$s_uv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 359.9093$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.09334389$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04483859$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.11468265$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05508886$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$\mu_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 998297.143$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.4029$

$V_u = 0.0005439$

$d = 0.8 * h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $Col_{j1} = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$

$s/d = 0.3125$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$

$s/d = 1.5625$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 998297.143$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.4024$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.1666667$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.3125$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 0.00$

$s/d = 1.5625$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$b_w = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlc

Constant Properties

Knowledge Factor, $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

· New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 · New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 · Concrete Elasticity, $E_c = 26999.444$
 · Steel Elasticity, $E_s = 200000.00$
 · Existing Column
 · Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 · Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 · Concrete Elasticity, $E_c = 21019.039$
 · Steel Elasticity, $E_s = 200000.00$
 · #####
 · Note: Especially for the calculation of moment strengths,
 · the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 · Jacket
 · New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
 · Existing Column
 · Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$
 · #####
 · Max Height, $H_{max} = 750.00$
 · Min Height, $H_{min} = 400.00$
 · Max Width, $W_{max} = 750.00$
 · Min Width, $W_{min} = 400.00$
 · Jacket Thickness, $t_j = 100.00$
 · Cover Thickness, $c = 25.00$
 · Mean Confinement Factor overall section = 1.00
 · Element Length, $L = 3000.00$
 · Secondary Member
 · Ribbed Bars
 · Ductile Steel
 · Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 · Longitudinal Bars With Ends Lapped Starting at the End Sections
 · Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
 · No FRP Wrapping
 · -----
 · Stepwise Properties
 · -----
 · At local axis: 2
 · EDGE -A-
 · Shear Force, $V_a = -0.0005439$
 · EDGE -B-
 · Shear Force, $V_b = 0.0005439$
 · BOTH EDGES
 · Axial Force, $F = -16323.501$
 · Longitudinal Reinforcement Area Distribution (in 2 divisions)
 · -Tension: $A_{sl,t} = 0.00$
 · -Compression: $A_{sl,c} = 5969.026$
 · Longitudinal Reinforcement Area Distribution (in 3 divisions)
 · -Tension: $A_{sl,ten} = 1137.257$
 · -Compression: $A_{sl,com} = 2362.478$
 · -Middle: $A_{sl,mid} = 2469.292$
 · -----
 · -----
 · Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$
 · Member Controlled by Flexure ($V_e/V_r < 1$)
 · Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$
 · with
 · $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$
 · $M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 · which is defined for the static loading combination
 · $M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 · direction which is defined for the static loading combination
 · $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$
 · $M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 · which is defined for the static loading combination
 · $M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

Calculation of Mu1+

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.5055191E-006$$

$$Mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsy = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.02714524$$

$$2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.05651029$$

$$v = A_{s1,mid}/(b*d)*(f_{sv}/f_c) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
v < v_{s,y2} - LHS eq.(4.5) is satisfied

$$\text{su (4.9)} = 0.14856848$$

$$\text{Mu} = \text{MRc (4.14)} = 5.0139\text{E}+008$$

$$u = \text{su (4.1)} = 8.5055191\text{E}-006$$

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772\text{E}-006$$

$$\text{Mu} = 8.4307\text{E}+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00791261
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00791261

$$w_e \text{ (5.4c)} = 0.01216945$$

$$ase \text{ ((5.4d), TBDY)} = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.45746528$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max1} = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

A_{conf,min1} = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max1} by a length equal to half the clear spacing between external hoops.

A_{noConf1} = 158733.333 is the unconfined external core area which is equal to b_i²/6 as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max2} = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

A_{conf,min2} = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max2} by a length equal to half the clear spacing between internal hoops.

A_{noConf2} = 106242.667 is the unconfined internal core area which is equal to b_i²/6 as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for p_{sh,min}*F_{ywe} has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1$, $sh1,ft1,fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 359.9093$$

$$\text{with } Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.09334389$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.04483859$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

c = confinement factor = 1.00

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.11468265$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.05508886$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.22227278$$

$$Mu = MRc (4.14) = 8.4307E+008$$

$$u = su (4.1) = 9.3115772E-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of $Mu2+$

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191E-006$$

$$Mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00791261$$

$$\text{we (5.4c) } = 0.01216945$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.45746528$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1) / Aconf,max1) * (Aconf,min1 / Aconf,max1), 0) = 0.45746528$$

The definitions of $AnoConf$, $Aconf,min$ and $Aconf,max$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$Aconf,max1 = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$Aconf,min1 = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase_2 (>= ase_1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$
 L_{stir1} (Length of stirrups along Y) = 2060.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$
 L_{stir2} (Length of stirrups along Y) = 1468.00
 A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$
 L_{stir1} (Length of stirrups along X) = 2060.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$
 L_{stir2} (Length of stirrups along X) = 1468.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal} ((5.5), \text{TBDY}) = 0.032$

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 $fs_1 = fs_1/1.2$, 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 $fs_1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9484$

with $Es_1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2_nominal} ((5.5), TBDY) = 0.032$$

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.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s1,com,jacket} + f_{s,core} * A_{s1,com,core}) / A_{s1,com} = 368.7326$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s1,com,jacket} + E_{s,core} * A_{s1,com,core}) / A_{s1,com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$$

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.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s1,mid,jacket} + f_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 359.9093$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s1,mid,jacket} + E_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 200000.00$$

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.02391392$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.04978341$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.02714524$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.05651029$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.14856848$$

$$M_u = M_{Rc} (4.14) = 5.0139E+008$$

$$u = s_u (4.1) = 8.5055191E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$M_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of $A_{noConf1}$, $A_{conf,min1}$ and $A_{conf,max1}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389

2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859

v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265

2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886

v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.22227278

Mu = MRc (4.14) = 8.4307E+008

u = su (4.1) = 9.3115772E-006

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 998297.143$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.5735$

$V_u = 0.0005439$

$d = 0.8 * h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$ is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $Col_{j1} = 1.00$

$s/d = 0.3125$

$V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$

$s/d = 0.16666667$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col_{c1} = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$ is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col_{c2} = 1.00$

$s/d = 0.56818182$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 998297.143$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 326.5741$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$ is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

$s/d = 0.3125$

$V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$s/d = 0.16666667$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$ is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

$s/d = 0.56818182$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$bw = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjlc

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 400.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -101183.60$
Shear Force, $V_2 = 7874.616$
Shear Force, $V_3 = -112.3724$
Axial Force, $F = -17081.857$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1137.257$
-Compression: $A_{sc,com} = 2362.478$
-Middle: $A_{sc,mid} = 2469.292$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten,jacket} = 829.3805$
-Compression: $A_{sc,com,jacket} = 1746.726$
-Middle: $A_{sc,mid,jacket} = 1545.664$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten,core} = 307.8761$
-Compression: $A_{sc,com,core} = 615.7522$
-Middle: $A_{sc,mid,core} = 923.6282$
Mean Diameter of Tension Reinforcement, $D_bL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.00076532$
 $u = y + p = 0.00076532$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00076532$ ((4.29), Biskinis Phd))
 $M_y = 3.6949E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 900.4311
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$
factor = 0.30
 $A_g = 440000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$
 $N = 17081.857$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$

web width, $b_w = 400.00$

flange thickness, $t = 400.00$

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 2.5827649\text{E-}006$$

$$\text{with } ((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 291.9465$$

$$d = 707.00$$

$$y = 0.20059112$$

$$A = 0.01136735$$

$$B = 0.00499612$$

$$\text{with } p_t = 0.00434791$$

$$p_c = 0.0044554$$

$$p_v = 0.00465684$$

$$N = 17081.857$$

$$b = 750.00$$

$$" = 0.06082037$$

$$y_{\text{comp}} = 1.5663730\text{E-}005$$

with $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.19866301$$

$$A = 0.01118379$$

$$B = 0.00488577$$

$$\text{with } E_s = 200000.00$$

CONFIRMATION: $y = 0.19957893 < t/d$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/d < 1$

$$\text{shear control ratio } V_y/E/V_{CoI}OE = 0.56300412$$

$$d = d_{\text{external}} = 707.00$$

$$s = s_{\text{external}} = 0.00$$

$$- t = s_1 + s_2 + 2 \cdot t_f/b_w \cdot (f_{fe}/f_s) = 0.00434791$$

$$\text{jacket: } s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00367709$$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2060.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00067082$$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

The term $2 \cdot t_f/b_w \cdot (f_{fe}/f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f/b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe}/f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$N_{UD} = 17081.857$$

$$A_g = 440000.00$$

$$f_cE = (f_c \cdot \text{Area}_{\text{jacket}} + f_c \cdot \text{Area}_{\text{core}}) / \text{section_area} = 27.68182$$

$$f_yE = (f_y \cdot \text{ext_Long_Reinf} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_y \cdot \text{int_Long_Reinf} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 521.1696$$

$$f_{yT}E = (f_y \cdot \text{ext_Trans_Reinf} \cdot s_1 + f_y \cdot \text{int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$$

$$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.011257$$

b = 750.00
d = 707.00
f_{cE} = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

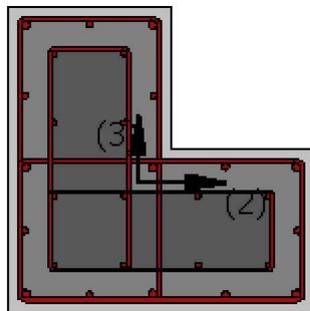
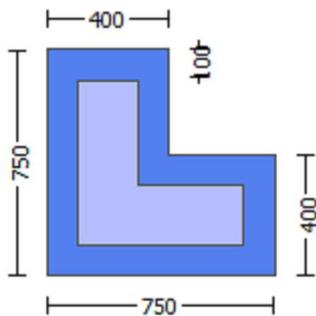
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjlc

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 444.4444$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -233750.983$

Shear Force, $V_a = 112.3724$

EDGE -B-

Bending Moment, $M_b = -101183.60$

Shear Force, $V_b = -112.3724$

BOTH EDGES

Axial Force, $F = -17081.857$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 0.00$

-Compression: $A_{slc} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1137.257$

-Compression: $A_{sl,com} = 2362.478$

-Middle: $A_{sl,mid} = 2469.292$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 1.0166E+006$

V_n ((10.3), ASCE 41-17) = $k_n l V_{CoI} = 1.0166E+006$

$V_{CoI} = 1.0166E+006$

$k_n l = 1.00$

displacement_ductility_demand = $4.0853875E-005$

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + \phi V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} \text{Area}_{jacket} + f'_{c_core} \text{Area}_{core}) / \text{Area}_{section} = 21.31818$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 101183.60$

$V_u = 112.3724$

$d = 0.8 \cdot h = 600.00$
 $Nu = 17081.857$
 $Ag = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 793340.11$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$
 $V_{s,j1} = 471238.898$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 251327.412$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 70773.799$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 736127.561$
 $bw = 400.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 3.1266345E-008$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00076532$ ((4.29), Biskinis Phd))
 $M_y = 3.6949E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 900.4311
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.4491E+014$
 $factor = 0.30$
 $Ag = 440000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$
 $N = 17081.857$
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$
 web width, $bw = 400.00$
 flange thickness, $t = 400.00$

y = Min(y_ten, y_com)
y_ten = 2.5827649E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/d)^ 2/3) = 291.9465
d = 707.00
y = 0.20059112
A = 0.01136735
B = 0.00499612
with pt = 0.00214476
pc = 0.0044554
pv = 0.00465684
N = 17081.857
b = 750.00
" = 0.06082037
y_comp = 1.5663730E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866301
A = 0.01118379
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19957893 < t/d

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

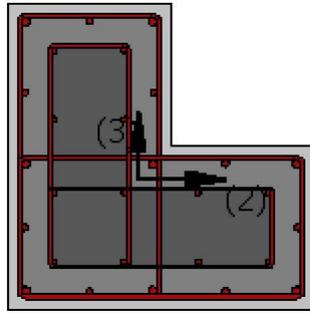
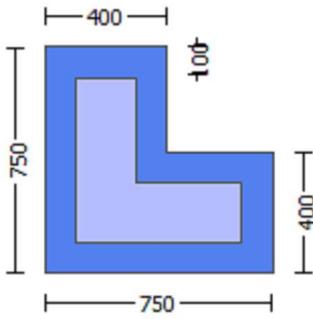
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$

 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
 Existing Column
 Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$
 #####

Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 400.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00
 Element Length, $L = 3000.00$

Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -0.0005439$
 EDGE -B-
 Shear Force, $V_b = 0.0005439$

BOTH EDGES

Axial Force, $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{ten} = 1137.257$

-Compression: $As_{com} = 2362.478$

-Middle: $As_{mid} = 2469.292$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$

$M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$

$M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

$\omega (5A.5, \text{TBDY}) = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00791261$

$\omega_e (5.4c) = 0.01216945$

$\omega_{ase} ((5.4d), \text{TBDY}) = (\omega_{ase1} * A_{ext} + \omega_{ase2} * A_{int}) / A_{sec} = 0.45746528$

$\omega_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\omega_{ase2} (>= \omega_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su1 = 0.4 * esu1_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with $Es1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su2 = 0.4 * esu2_{nominal}$ ((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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$

with $Es2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14856848

Mu = MRc (4.14) = 5.0139E+008

u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00174912

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00791261

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1) * (Aconf,min1/Aconf,max1), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.92621$$

Expression (5.4d) for psh,min * Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fsjacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 368.7326$$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2/1.2$, 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 $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 367.9484$
 with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 431.8911$
 $fy_v = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_d = 0.30$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_v = fs_v/1.2$, 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 $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 359.9093$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.093334389$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.04483859$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / f_c) = 0.09522963$

and confined core properties:

$b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.11468265$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.05508886$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / f_c) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_s, y_2$ - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.22227278$
 $M_u = MR_c (4.14) = 8.4307E+008$
 $u = su (4.1) = 9.3115772E-006$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of M_{u2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191E-006$$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\omega (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00791261$$

$$\omega_e (5.4c) = 0.01216945$$

$$\text{ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.45746528$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{ase2} (>= \text{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.538$$

$$fy1 = 367.9484$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 367.9484$$

$$\text{with } Es1 = (Es_jacket * Asl,ten,jacket + Es_core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 442.4791$$

$$fy2 = 368.7326$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 368.7326$$

$$\text{with } Es2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 431.8911$$

$$fyv = 359.9093$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 359.9093$$

$$\text{with } Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.02391392$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.04978341$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.02714524$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.05651029$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.14856848$$

$$\mu_u = M_{Rc}(4.14) = 5.0139E+008$$

$$u = s_u(4.1) = 8.5055191E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e(5.4c) = 0.01216945$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1}(\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$p_{sh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.92621
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00367709
Lstir₁ (Length of stirrups along X) = 2060.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00067082
Lstir₂ (Length of stirrups along X) = 1468.00
Astir₂ (stirrups area) = 50.26548

Asec = 440000.00
s₁ = 100.00
s₂ = 250.00

fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y₁ = 0.00140044
sh₁ = 0.0044814
ft₁ = 442.4791
fy₁ = 368.7326
su₁ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 0.30

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} = 368.7326

with Es₁ = (Es_{jacket}*Asl_{ten,jacket} + Es_{core}*Asl_{ten,core})/Asl_{ten} = 200000.00

y₂ = 0.00140044
sh₂ = 0.0044814

ft₂ = 441.538
fy₂ = 367.9484
su₂ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_{b,min} = 0.30

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.

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} = 367.9484

with Es₂ = (Es_{jacket}*Asl_{com,jacket} + Es_{core}*Asl_{com,core})/Asl_{com} = 200000.00

y_v = 0.00140044
sh_v = 0.0044814

ft_v = 431.8911
fy_v = 359.9093
su_v = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 0.30

su_v = 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} = 359.9093

$$\text{with } E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09334389$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483859$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.11468265$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508886$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$M_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 998297.143$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

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: $f'_c = (f'_c \cdot A_{jacket} + f'_c \cdot A_{core}) / A_{section} = 27.68182$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$M_u = 326.4029$$

$$V_u = 0.0005439$$

$$d = 0.8 \cdot h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

where:

$$V_{s,jacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col,j1 = 1.00$

$$s/d = 0.16666667$$

$V_{sj2} = 279252.68$ is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col,j2 = 1.00$

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$

$$s/d = 1.5625$$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$$bw = 400.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$$V_{Col0} = 998297.143$$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 326.4024$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

$$s/d = 0.16666667$$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

V_{s,c2} is multiplied by Col,c2 = 0.00
s/d = 1.5625
V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: V_s + V_f <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjls

Constant Properties

Knowledge Factor, γ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$
#####

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 400.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -0.0005439$
EDGE -B-
Shear Force, $V_b = 0.0005439$
BOTH EDGES
Axial Force, $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1137.257$

-Compression: $A_{sc,com} = 2362.478$

-Middle: $A_{st,mid} = 2469.292$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$

$M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$

$M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00791261$

w_e (5.4c) = 0.01216945

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

c = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with $Es_1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 * esu_{2,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$

with $Es_2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$$f_{tv} = 431.8911$$

$$f_{yv} = 359.9093$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

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, f_{tv}, f_{yv} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 359.9093$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.02391392$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04978341$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$c =$ confinement factor = 1.00

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.02714524$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05651029$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14856848$$

$$M_u = M_{Rc} (4.14) = 5.0139E+008$$

$$u = s_u (4.1) = 8.5055191E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u1 -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$M_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00791261$$

$$\phi_{co} (5.4c) = 0.01216945$$

$$\text{ase ((5.4d), TBDY) = } (\text{ase1} * A_{ext} + \text{ase2} * A_{int}) / A_{sec} = 0.45746528$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

Expression (5.4d) for $psh_{min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{u,min} = l_b/l_d = 0.30$

$su1 = 0.4 * esu1_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered

characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 368.7326$

with $Es1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y2 = 0.00140044$

$sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{min} = lb/lb_{min} = 0.30$
 $su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2_nominal} = 0.08$,
 For calculation of $esu_{2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9484$
 with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $yv = 0.00140044$
 $shv = 0.0044814$
 $ftv = 431.8911$
 $fyv = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv , shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$
 with $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09334389$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04483859$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.09522963$
 and confined core properties:
 $b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.11468265$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05508886$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.11699947$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22227278$
 $Mu = MRc (4.14) = 8.4307E+008$
 $u = su (4.1) = 9.3115772E-006$

 Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.5055191E-006$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4*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 = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044
sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044
shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

$$\begin{aligned} su(4.9) &= 0.14856848 \\ \mu &= MRc(4.14) = 5.0139E+008 \\ u &= su(4.1) = 8.5055191E-006 \end{aligned}$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_2

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\begin{aligned} u &= 9.3115772E-006 \\ \mu &= 8.4307E+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 400.00 \\ d &= 707.00 \\ d' &= 43.00 \\ v &= 0.00174912 \\ N &= 16323.501 \end{aligned}$$

$$\begin{aligned} f_c &= 33.00 \\ c_o(5A.5, TBDY) &= 0.002 \\ \text{Final value of } c_u: c_u^* &= \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261 \end{aligned}$$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.00791261$

$$w_e(5.4c) = 0.01216945$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1}(\text{Length of stirrups along } Y) = 2060.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$p_{sh2}((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2}(\text{Length of stirrups along } Y) = 1468.00$$

$$A_{stir2}(\text{stirrups area}) = 50.26548$$

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.92621
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00367709
Lstir₁ (Length of stirrups along X) = 2060.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00067082
Lstir₂ (Length of stirrups along X) = 1468.00
Astir₂ (stirrups area) = 50.26548

Asec = 440000.00
s₁ = 100.00
s₂ = 250.00

fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y₁ = 0.00140044
sh₁ = 0.0044814
ft₁ = 442.4791
fy₁ = 368.7326
su₁ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

su₁ = 0.4*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 = 368.7326

with Es₁ = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y₂ = 0.00140044
sh₂ = 0.0044814

ft₂ = 441.538
fy₂ = 367.9484

su₂ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su₂ = 0.4*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 = 367.9484

with Es₂ = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

y_v = 0.00140044
sh_v = 0.0044814

ft_v = 431.8911
fy_v = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and y_v, sh_v,ft_v,fy_v, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs₁/fc) = 0.09334389

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.04483859$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$\mu_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 998297.143$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 326.5735$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

where:

$$V_{s,jacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 279252.68$ is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$$s/d = 0.3125$$

$V_{sj2} = 523598.776$ is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$$s/d = 0.16666667$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_r2 = 998297.143$
 $V_r2 = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l * V_{Col0}$
 $V_{Col0} = 998297.143$
 $k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 4.00$
 $M_u = 326.5741$
 $V_u = 0.0005439$
 $d = 0.8 * h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$

Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 400.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 105242.575$
Shear Force, $V_2 = 7874.616$
Shear Force, $V_3 = -112.3724$
Axial Force, $F = -17081.857$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1137.257$
-Compression: $A_{sl,com} = 2362.478$
-Middle: $A_{sl,mid} = 2469.292$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten,jacket} = 829.3805$
-Compression: $A_{sl,com,jacket} = 1746.726$
-Middle: $A_{sl,mid,jacket} = 1545.664$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten,core} = 307.8761$

-Compression: $A_{sl,com,core} = 615.7522$

-Middle: $A_{sl,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = u = 0.00025498$
 $u = y + p = 0.00025498$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00025498$ ((4.29), Biskinis Phd))

$M_y = 3.6949E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$

factor = 0.30

$A_g = 440000.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$

$N = 17081.857$

$E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$

web width, $b_w = 400.00$

flange thickness, $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 2.5827649E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.20059112$

$A = 0.01136735$

$B = 0.00499612$

with $pt = 0.00434791$

$pc = 0.0044554$

$pv = 0.00465684$

$N = 17081.857$

$b = 750.00$

$\rho = 0.06082037$

$y_{comp} = 1.5663730E-005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866301$

$A = 0.01118379$

$B = 0.00488577$

with $E_s = 200000.00$

CONFIRMATION: $y = 0.19957893 < t/d$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{CoI} O E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$

jacket: $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00367709$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2060.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00067082$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$N_{UD} = 17081.857$

$A_g = 440000.00$

$f_{cE} = (f_{c_jacket} * Area_jacket + f_{c_core} * Area_core) / section_area = 27.68182$

$f_{yE} = (f_{y_ext_Long_Reinf} * Area_ext_Long_Reinf + f_{y_int_Long_Reinf} * Area_int_Long_Reinf) / Area_Tot_Long_Rein = 521.1696$

$f_{yE} = (f_{y_ext_Trans_Reinf} * s_1 + f_{y_int_Trans_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$\rho_l = Area_Tot_Long_Rein / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

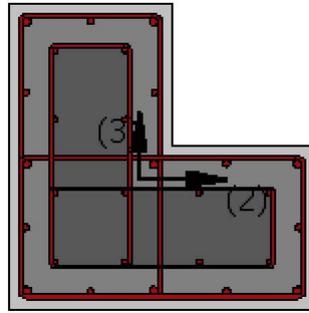
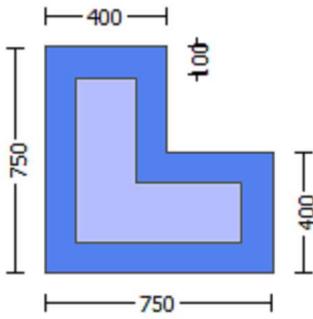
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 444.4444$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.9722E+007$

Shear Force, $V_a = -6543.324$
EDGE -B-
Bending Moment, $M_b = 87505.349$
Shear Force, $V_b = 6543.324$
BOTH EDGES
Axial Force, $F = -16953.648$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1137.257$
-Compression: $A_{sc,com} = 2362.478$
-Middle: $A_{st,mid} = 2469.292$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 876327.526$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 876327.526$
 $V_{CoI} = 876327.526$
 $k_n = 1.00$
displacement_ductility_demand = 0.03084783

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + \phi \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 21.31818$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 4.00$
 $\mu = 1.9722E+007$
 $V_u = 6543.324$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16953.648$
 $A_g = 300000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 793340.11$
where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$
 $V_{s,j1} = 251327.412$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 471238.898$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 70773.799$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

$s/d = 0.56818182$
 $V_f((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 736127.561$
 $b_w = 400.00$

displacement_ductility_demand is calculated as ϕ_y

- Calculation of ϕ_y for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation $\theta = 7.9019201E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00256158$ ((4.29), Biskinis Phd))
 $M_y = 3.6946E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3014.111
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 1.4491E+014$
factor = 0.30
 $A_g = 440000.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} * \text{Area}_{jacket} + f'_{c_core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182$
 $N = 16953.648$
 $E_c * I_g = E_{c_jacket} * I_{g_jacket} + E_{c_core} * I_{g_core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:
flange width, $b = 750.00$
web width, $b_w = 400.00$
flange thickness, $t = 400.00$

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 2.5827092E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/d)^{2/3}) = 291.9465$
 $d = 707.00$
 $y = 0.2005739$
 $A = 0.01136652$
 $B = 0.00499529$
with $pt = 0.00214476$
 $pc = 0.0044554$
 $pv = 0.00465684$
 $N = 16953.648$
 $b = 750.00$
 $\lambda = 0.06082037$
 $y_{comp} = 1.5663957E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19866014$
 $A = 0.01118434$
 $B = 0.00488577$
with $E_s = 200000.00$
CONFIRMATION: $y = 0.19956922 < t/d$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

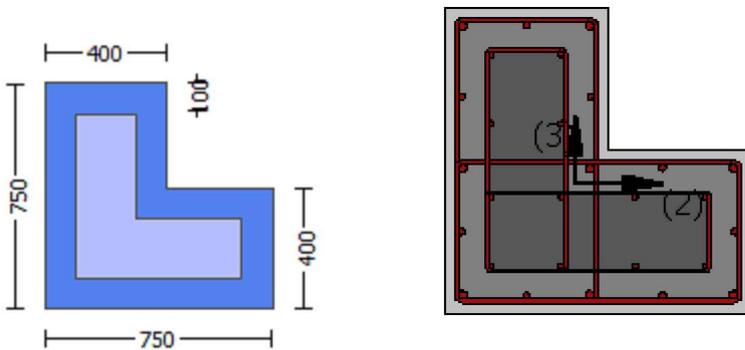
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjlc

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.0005439
EDGE -B-
Shear Force, Vb = 0.0005439
BOTH EDGES
Axial Force, F = -16323.501
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Asl,t = 0.00
-Compression: Asl,c = 5969.026
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2362.478
-Middle: Asl,mid = 2469.292

Calculation of Shear Capacity ratio , $V_e/V_r = 0.56300412$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$
with
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 8.4307E+008$
 $\mu_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 8.4307E+008$
 $\mu_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.5055191E-006$
 $M_u = 5.0139E+008$

with full section properties:

b = 750.00
d = 707.00
d' = 43.00
v = 0.00093286
N = 16323.501
fc = 33.00

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$\text{ase (5.4d), TBDY} = (\text{ase1} * A_{\text{ext}} + \text{ase2} * A_{\text{int}}) / A_{\text{sec}} = 0.45746528$$

$$\text{ase1} = \text{Max}(((A_{\text{conf,max1}} - A_{\text{noConf1}}) / A_{\text{conf,max1}}) * (A_{\text{conf,min1}} / A_{\text{conf,max1}}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{\text{conf,min}}$ and $A_{\text{conf,max}}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max1}} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{\text{conf,min1}} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{\text{conf,max1}}$ by a length

equal to half the clear spacing between external hoops.

$A_{\text{noConf1}} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{ase2} (> = \text{ase1}) = \text{Max}(((A_{\text{conf,max2}} - A_{\text{noConf2}}) / A_{\text{conf,max2}}) * (A_{\text{conf,min2}} / A_{\text{conf,max2}}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{\text{conf,min}}$ and $A_{\text{conf,max}}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max2}} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{\text{conf,min2}} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{\text{conf,max2}}$ by a length

equal to half the clear spacing between internal hoops.

$A_{\text{noConf2}} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{\text{sh,min}} * F_{ywe} = \text{Min}(p_{\text{sh,x}} * F_{ywe}, p_{\text{sh,y}} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{\text{sh,min}} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{\text{sh,x}} * F_{ywe} = p_{\text{sh1}} * F_{ywe1} + p_{\text{sh2}} * F_{ywe2} = 2.92621$$

$$p_{\text{sh1}} \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00367709$$

$$L_{\text{stir1}} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{\text{stir1}} \text{ (stirrups area)} = 78.53982$$

$$p_{\text{sh2}} \text{ (5.4d)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00067082$$

$$L_{\text{stir2}} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{\text{stir2}} \text{ (stirrups area)} = 50.26548$$

$$p_{\text{sh,y}} * F_{ywe} = p_{\text{sh1}} * F_{ywe1} + p_{\text{sh2}} * F_{ywe2} = 2.92621$$

$$p_{\text{sh1}} \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00367709$$

$$L_{\text{stir1}} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{\text{stir1}} \text{ (stirrups area)} = 78.53982$$

$$p_{\text{sh2}} \text{ ((5.4d), TBDY)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00067082$$

$$L_{\text{stir2}} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{\text{stir2}} \text{ (stirrups area)} = 50.26548$$

$$A_{\text{sec}} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.538$$

$$fy1 = 367.9484$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o / l_{o,\text{min}} = l_b / l_d = 0.30$$

$$su_1 = 0.4 * esu_{1_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{1_nominal} = 0.08$,

For calculation of $esu_{1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 367.9484$$

$$\text{with } Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 442.4791$$

$$fy_2 = 368.7326$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/lb_{min} = 0.30$$

$$su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2_nominal} = 0.08$,

For calculation of $esu_{2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 368.7326$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$$

$$\text{with } Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.02391392$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04978341$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.02714524$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05651029$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.14856848$$

$$Mu = MRc (4.14) = 5.0139E+008$$

$$u = su (4.1) = 8.5055191E-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu1-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

Asec = 440000.00
 s1 = 100.00
 s2 = 250.00
 fywe1 = 694.4444
 fywe2 = 555.5556
 fce = 33.00
 From ((5.A.5), TBDY), TBDY: cc = 0.002
 c = confinement factor = 1.00
 y1 = 0.00140044
 sh1 = 0.0044814
 ft1 = 442.4791
 fy1 = 368.7326
 su1 = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 lo/lou,min = lb/lb = 0.30
 su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: esu1_nominal = 0.08,
 For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
 characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
 y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326
 with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
 y2 = 0.00140044
 sh2 = 0.0044814
 ft2 = 441.538
 fy2 = 367.9484
 su2 = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 lo/lou,min = lb/lb,min = 0.30
 su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: esu2_nominal = 0.08,
 For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
 characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
 y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484
 with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
 yv = 0.00140044
 shv = 0.0044814
 ftv = 431.8911
 fyv = 359.9093
 suv = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 lo/lou,min = lb/lb = 0.30
 suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: esuv_nominal = 0.08,
 considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
 For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
 characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
 y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093
 with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
 1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
 2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
 v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
 and confined core properties:
 b = 340.00
 d = 677.00
 d' = 13.00
 fcc (5A.2, TBDY) = 33.00
 cc (5A.5, TBDY) = 0.002
 c = confinement factor = 1.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture
satisfies Eq. (4.3)

--->
v < v_{s,y2} - LHS eq.(4.5) is satisfied

$$\text{su (4.9)} = 0.22227278$$

$$\text{Mu} = \text{MRc (4.14)} = 8.4307\text{E}+008$$

$$u = \text{su (4.1)} = 9.3115772\text{E}-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191\text{E}-006$$

$$\text{Mu} = 5.0139\text{E}+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00791261$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00791261$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$ase \text{ ((5.4d), TBDY)} = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max1} = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

A_{conf,min1} = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max1} by a length equal to half the clear spacing between external hoops.

A_{noConf1} = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max2} = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

A_{conf,min2} = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max2} by a length equal to half the clear spacing between internal hoops.

A_{noConf2} = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for p_{sh,min}*F_{ywe} has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044
sh2 = 0.0044814
ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
considering characteristic value $f_{sy} = f_{sv}/1.2$, 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 $f_{sy} = f_{sv}/1.2$, 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 $f_{sv} = (f_{s,jacket} \cdot A_{s1,mid,jacket} + f_{s,mid} \cdot A_{s1,mid,core}) / A_{s1,mid} = 359.9093$

with $E_{sv} = (E_{s,jacket} \cdot A_{s1,mid,jacket} + E_{s,mid} \cdot A_{s1,mid,core}) / A_{s1,mid} = 200000.00$

1 = $A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02391392$

2 = $A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04978341$

$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02714524$

2 = $A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05651029$

$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.14856848

$Mu = MR_c$ (4.14) = 5.0139E+008

$u = su$ (4.1) = 8.5055191E-006

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 9.3115772E-006$

$Mu = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174912$

$N = 16323.501$

$f_c = 33.00$

cc (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00791261$

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - \text{AnoConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $psh_{,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $psh_{,x} * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$
 $psh1 ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
 $psh2 ((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

 $psh_{,y} * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$
 $psh1 ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
 $psh2 ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 368.7326

with Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

$$su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{,com,jacket} + fs_{core} * Asl_{,com,core}) / Asl_{,com} = 367.9484$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{,com,jacket} + Es_{core} * Asl_{,com,core}) / Asl_{,com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fs_v = fs_v/1.2$, 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.

$$\text{with } fs_v = (fs_{jacket} * Asl_{,mid,jacket} + fs_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 359.9093$$

$$\text{with } Es_v = (Es_{jacket} * Asl_{,mid,jacket} + Es_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 200000.00$$

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.09334389$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.04483859$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.11468265$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.05508886$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

'satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.22227278$$

$$\mu_u = MR_c (4.14) = 8.4307E+008$$

$$u = su (4.1) = 9.3115772E-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$$

$$V_{Col0} = 998297.143$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * fy * d / s$ ' 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: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $fc'^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$
 $\mu_u = 326.4029$
 $\nu_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 881489.011$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 279252.68$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $b_w = 400.00$

 Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 998297.143$
 $knl = 1$ (zero step-static loading)

 NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$
 $\mu_u = 326.4024$
 $\nu_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 881489.011$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$

$s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcjlc

Constant Properties

Knowledge Factor, $= 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
 Existing Column
 Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -0.0005439$
EDGE -B-
Shear Force, $V_b = 0.0005439$
BOTH EDGES
Axial Force, $F = -16323.501$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1137.257$
-Compression: $A_{sc,com} = 2362.478$
-Middle: $A_{st,mid} = 2469.292$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$
 $M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$
 $M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.5055191E-006$
 $M_u = 5.0139E+008$

with full section properties:

$b = 750.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093286$
 $N = 16323.501$
 $f_c = 33.00$
 ϕ_o (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.00791261$

w_e (5.4c) = 0.01216945

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.002$

c = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 0.30$

$su1 = 0.4 * e_{su1,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $e_{su1,nominal} = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 367.9484$

with $Es1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lo_{ou,min} = lb/lb_{,min} = 0.30$

$su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 368.7326$

with $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 431.8911$

$fyv = 359.9093$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lo_{ou,min} = lb/ld = 0.30$

$suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs_{y2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14856848$

$Mu = MRc (4.14) = 5.0139E+008$

$u = su (4.1) = 8.5055191E-006$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu1-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 9.3115772E-006$$

$$\text{Mu} = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$s_2 = 250.00$
 $fy_{we1} = 694.4444$
 $fy_{we2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00140044$
 $sh_1 = 0.0044814$
 $ft_1 = 442.4791$
 $fy_1 = 368.7326$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * A_{sl, ten, jacket} + fs_{core} * A_{sl, ten, core}) / A_{sl, ten} = 368.7326$
 with $Es_1 = (Es_{jacket} * A_{sl, ten, jacket} + Es_{core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl, com, jacket} + fs_{core} * A_{sl, com, core}) / A_{sl, com} = 367.9484$
 with $Es_2 = (Es_{jacket} * A_{sl, com, jacket} + Es_{core} * A_{sl, com, core}) / A_{sl, com} = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 431.8911$
 $fy_v = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * A_{sl, mid, jacket} + fs_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 359.9093$
 with $Es_v = (Es_{jacket} * A_{sl, mid, jacket} + Es_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 200000.00$
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.09334389$
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.04483859$
 $v = A_{sl, mid} / (b * d) * (fsv / f_c) = 0.09522963$
 and confined core properties:
 $b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.11468265$
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.05508886$

$$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture
 satisfies Eq. (4.3)

--->

$v < v_{s, y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.22227278$$

$$M_u = M_{Rc}(4.14) = 8.4307E+008$$

$$u = s_u(4.1) = 9.3115772E-006$$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

Calculation of M_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191E-006$$

$$M_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\alpha(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e(5.4c) = 0.01216945$$

$$a_{se}(5.4d, TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf, max1} - A_{noConf1}) / A_{conf, max1}) * (A_{conf, min1} / A_{conf, max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf, min}$ and $A_{conf, max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf, max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf, min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf, max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf, max2} - A_{noConf2}) / A_{conf, max2}) * (A_{conf, min2} / A_{conf, max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf, min}$ and $A_{conf, max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf, max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf, min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf, max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh, min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh, min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 0.30

su1 = $0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = $(f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 367.9484$

with Es1 = $(E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_b,min = 0.30

su2 = $0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = $(f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 368.7326$

with Es2 = $(E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 0.30

suv = $0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and γ_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

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 $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 359.9093$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02391392$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04978341$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02714524$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05651029$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14856848$

$Mu = MRc (4.14) = 5.0139E+008$

$u = su (4.1) = 8.5055191E-006$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 9.3115772E-006$

$Mu = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174912$

$N = 16323.501$

$f_c = 33.00$

$cc (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00791261$

$w_e (5.4c) = 0.01216945$

$ase ((5.4d), TBDY) = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.92621$$

Expression (5.4d) for psh,min * Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh,x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh,y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/l_d = 0.30$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 368.7326$$

$$\text{with } Es1 = (Es_jacket * Asl,ten,jacket + Es_core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/l_b,min = 0.30$$

$$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of $es_{u2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 367.9484$

with $Es_2 = (Es_{jacket} \cdot Asl_{,com,jacket} + Es_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 431.8911$

$fy_v = 359.9093$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo_{u,min} = lb/d = 0.30$

$suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = f_{sv}/1.2$, 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 $fs_{yv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot Asl_{,mid,jacket} + f_{s,mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 359.9093$

with $Es_v = (Es_{jacket} \cdot Asl_{,mid,jacket} + Es_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 200000.00$

$1 = Asl_{,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09334389$

$2 = Asl_{,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483859$

$v = Asl_{,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09522963$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = Asl_{,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.11468265$

$2 = Asl_{,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508886$

$v = Asl_{,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.22227278$

$Mu = MRc (4.14) = 8.4307E+008$

$u = su (4.1) = 9.3115772E-006$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{ColO}$

$V_{ColO} = 998297.143$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$Mu = 326.5735$

$V_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I \cdot V_{Col0}$
 $V_{Col0} = 998297.143$
 $k_n I = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $M_u = 326.5741$
 $V_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

s/d = 0.3125

$V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:

d = 600.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 100.00

$V_{s,j2}$ is multiplied by Col,j2 = 1.00

s/d = 0.16666667

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

d = 160.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c1}$ is multiplied by Col,c1 = 0.00

s/d = 1.5625

$V_{s,c2} = 78637.555$ is calculated for section flange core, with:

d = 440.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c2}$ is multiplied by Col,c2 = 1.00

s/d = 0.56818182

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjlc

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -194177.576$
Shear Force, $V_2 = -6543.324$
Shear Force, $V_3 = 93.37449$
Axial Force, $F = -16953.648$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 2362.478$
-Middle: $As_{c,mid} = 2469.292$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 829.3805$
-Compression: $As_{c,com,jacket} = 1746.726$
-Middle: $As_{c,mid,jacket} = 1545.664$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 307.8761$
-Compression: $As_{c,com,core} = 615.7522$
-Middle: $As_{c,mid,core} = 923.6282$
Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = u = 0.04073976$
 $u = y + p = 0.04073976$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00176734$ ((4.29), Biskinis Phd)
 $M_y = 3.6946E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 2079.557
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$
factor = 0.30
 $A_g = 440000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$
 $N = 16953.648$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:
flange width, $b = 750.00$
web width, $b_w = 400.00$
flange thickness, $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 2.5827092E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 291.9465$
 $d = 707.00$
 $y = 0.2005739$
 $A = 0.01136652$
 $B = 0.00499529$
with $pt = 0.00434791$
 $pc = 0.0044554$
 $pv = 0.00465684$

$N = 16953.648$
 $b = 750.00$
 $" = 0.06082037$
 $y_{comp} = 1.5663957E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19866014$
 $A = 0.01118434$
 $B = 0.00488577$
 with $E_s = 200000.00$
 CONFIRMATION: $y = 0.19956922 < t/d$

 Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.03897242$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{Col} O E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$

jacket: $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00367709$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2060.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00067082$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$N_{UD} = 16953.648$

$A_g = 440000.00$

$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section_area = 27.68182$

$f_{yIE} = (f_{y,ext_Long_Reinf} * Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} * Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 521.1696$

$f_{yIE} = (f_{y,ext_Trans_Reinf} * s_1 + f_{y,int_Trans_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$p_l = Area_{Tot_Long_Rein} / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

 End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

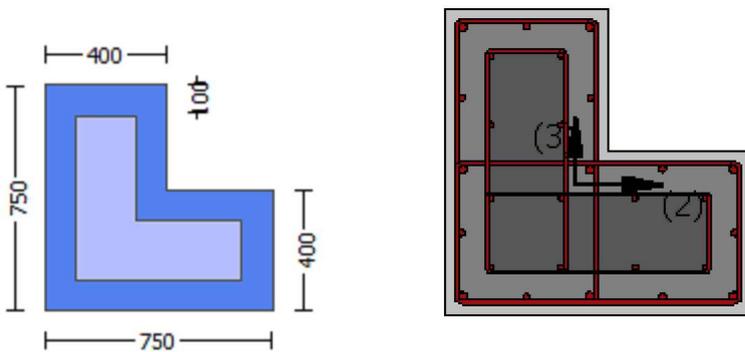
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 444.4444$

#####

Max Height, Hmax = 750.00
Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -194177.576
Shear Force, Va = 93.37449
EDGE -B-
Bending Moment, Mb = -84132.56
Shear Force, Vb = -93.37449
BOTH EDGES
Axial Force, F = -16953.648
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5969.026
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2362.478
-Middle: Asl,mid = 2469.292
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = $*V_n = 897931.212$
 $V_n ((10.3), ASCE 41-17) = knl * V_{CoI} = 897931.212$
 $V_{CoI} = 897931.212$
 $knl = 1.00$
 $displacement_ductility_demand = 0.0175448$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 21.31818$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 3.46593$
 $M_u = 194177.576$
 $V_u = 93.37449$
 $d = 0.8 * h = 600.00$
 $N_u = 16953.648$
 $A_g = 300000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 793340.11$
where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$
 $V_{s,j1} = 471238.898$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 251327.412$ is calculated for section flange jacket, with:

$d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 70773.799$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 736127.561$
 $bw = 400.00$

 displacement ductility demand is calculated as ϕ / y

- Calculation of ϕ / y for END A -
 for rotation axis 2 and integ. section (a)

 From analysis, chord rotation $\theta = 3.1007595E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00176734$ ((4.29), Biskinis Phd)
 $M_y = 3.6946E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 2079.557
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$
 $factor = 0.30$
 $A_g = 440000.00$
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$
 $N = 16953.648$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

 Calculation of Yielding Moment M_y

 Calculation of ϕ / y and M_y according to Annex 7 -

 Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:
 flange width, $b = 750.00$
 web width, $bw = 400.00$
 flange thickness, $t = 400.00$

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 2.5827092E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (b/d)^{2/3}) = 291.9465$
 $d = 707.00$
 $y = 0.2005739$
 $A = 0.01136652$
 $B = 0.00499529$
 with $pt = 0.00214476$
 $pc = 0.0044554$
 $pv = 0.00465684$
 $N = 16953.648$
 $b = 750.00$
 $\phi = 0.06082037$

y_comp = 1.5663957E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866014
A = 0.01118434
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19956922 < t/d

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

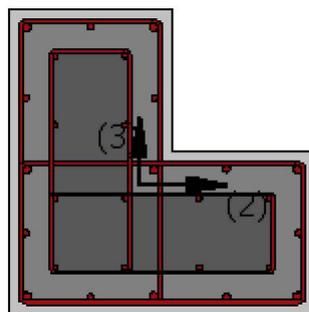
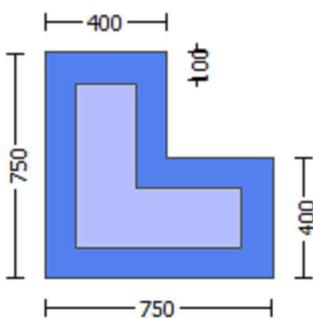
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjlc

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -0.0005439$

EDGE -B-

Shear Force, $V_b = 0.0005439$

BOTH EDGES

Axial Force, $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1137.257$

-Compression: $A_{sl,com} = 2362.478$

-Middle: $A_{sl,mid} = 2469.292$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$

$M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$

$M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction

which is defined for the the static loading combination

$\mu_{u-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00140044
sh1 = 0.0044814

ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044
sh2 = 0.0044814

ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044
shv = 0.0044814

ftv = 431.8911
fyv = 359.9093
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00
d = 677.00
d' = 13.00

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_s, y2$ - LHS eq.(4.5) is satisfied

$$su (4.9) = 0.14856848$$

$$Mu = MRc (4.14) = 5.0139E+008$$

$$u = su (4.1) = 8.5055191E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$Mu = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00791261$$

$$we (5.4c) = 0.01216945$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.45746528$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1) / Aconf,max1) * (Aconf,min1 / Aconf,max1), 0) = 0.45746528$$

The definitions of $AnoConf$, $Aconf,min$ and $Aconf,max$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$Aconf,max1 = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$Aconf,min1 = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $Aconf,max1$ by a length

equal to half the clear spacing between external hoops.

$AnoConf1 = 158733.333$ is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).

$$ase2 (> = ase1) = \text{Max}(((Aconf,max2 - AnoConf2) / Aconf,max2) * (Aconf,min2 / Aconf,max2), 0) = 0.45746528$$

The definitions of $AnoConf$, $Aconf,min$ and $Aconf,max$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$Aconf,max2 = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$Aconf,min2 = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $Aconf,max2$ by a length

equal to half the clear spacing between internal hoops.

$AnoConf2 = 106242.667$ is the unconfined internal core area which is equal to $bi^2/6$ as defined at (A.2).

$$psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 2.92621$$

Expression (5.4d) for $psh_{min} * Fy_{we}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/ld = 0.30$$

$$su1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 368.7326$$

$$\text{with } Es1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/lb_{min} = 0.30$$

$$su2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9484$$

$$\text{with } Es2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$su_v = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389

2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859

v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265

2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886

v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.22227278

Mu = MRc (4.14) = 8.4307E+008

u = su (4.1) = 9.3115772E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.5055191E-006

Mu = 5.0139E+008

with full section properties:

b = 750.00

d = 707.00

d' = 43.00

v = 0.00093286

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00791261

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528

ase1 = $\text{Max}(\frac{A_{\text{conf,max1}} - A_{\text{noConf1}}}{A_{\text{conf,max1}}} \cdot \frac{A_{\text{conf,min1}}}{A_{\text{conf,max1}}}, 0)$ = 0.45746528

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase_2 (>= ase_1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_0/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with $Es_1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14856848

Mu = MRc (4.14) = 5.0139E+008

u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (> a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along } X) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along } X) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$s_u1 = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su1,nominal} = 0.08$,

For calculation of $e_{su1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 368.7326$$

$$\text{with } E_{s1} = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.538$$

$$fy_2 = 367.9484$$

$$s_u2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 367.9484$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s,com,jacket} + E_{s,core} * A_{s,com,core}) / A_{s,com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$s_uv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 359.9093$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.09334389$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04483859$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.11468265$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05508886$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$\mu_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 998297.143$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.4029$

$V_u = 0.0005439$

$d = 0.8 * h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $Col_{j1} = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$

$s/d = 0.3125$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$

$s/d = 1.5625$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 998297.143$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.4024$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.3125$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 0.00$

$s/d = 1.5625$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$b_w = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlc

Constant Properties

Knowledge Factor, $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

· New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 · New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 · Concrete Elasticity, $E_c = 26999.444$
 · Steel Elasticity, $E_s = 200000.00$
 · Existing Column
 · Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 · Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 · Concrete Elasticity, $E_c = 21019.039$
 · Steel Elasticity, $E_s = 200000.00$
 · #####
 · Note: Especially for the calculation of moment strengths,
 · the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 · Jacket
 · New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
 · Existing Column
 · Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$
 · #####
 · Max Height, $H_{max} = 750.00$
 · Min Height, $H_{min} = 400.00$
 · Max Width, $W_{max} = 750.00$
 · Min Width, $W_{min} = 400.00$
 · Jacket Thickness, $t_j = 100.00$
 · Cover Thickness, $c = 25.00$
 · Mean Confinement Factor overall section = 1.00
 · Element Length, $L = 3000.00$
 · Secondary Member
 · Ribbed Bars
 · Ductile Steel
 · Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 · Longitudinal Bars With Ends Lapped Starting at the End Sections
 · Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
 · No FRP Wrapping
 · -----
 · Stepwise Properties
 · -----
 · At local axis: 2
 · EDGE -A-
 · Shear Force, $V_a = -0.0005439$
 · EDGE -B-
 · Shear Force, $V_b = 0.0005439$
 · BOTH EDGES
 · Axial Force, $F = -16323.501$
 · Longitudinal Reinforcement Area Distribution (in 2 divisions)
 · -Tension: $A_{sl} = 0.00$
 · -Compression: $A_{sl,c} = 5969.026$
 · Longitudinal Reinforcement Area Distribution (in 3 divisions)
 · -Tension: $A_{sl,ten} = 1137.257$
 · -Compression: $A_{sl,com} = 2362.478$
 · -Middle: $A_{sl,mid} = 2469.292$
 · -----
 · -----
 · Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$
 · Member Controlled by Flexure ($V_e/V_r < 1$)
 · Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$
 · with
 · $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.4307E+008$
 · $Mu_{1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 · which is defined for the static loading combination
 · $Mu_{1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 · direction which is defined for the static loading combination
 · $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 8.4307E+008$
 · $Mu_{2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 · which is defined for the static loading combination
 · $Mu_{2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.02714524$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05651029$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->
 $s_u(4.9) = 0.14856848$
 $M_u = M_{Rc}(4.14) = 5.0139E+008$
 $u = s_u(4.1) = 8.5055191E-006$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of M_{u1} -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$M_u = 8.4307E+008$$

 with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u * = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e(5.4c) = 0.01216945$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1$, $sh1,ft1,fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 359.9093$$

$$\text{with } Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.09334389$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.04483859$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

c = confinement factor = 1.00

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.11468265$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.05508886$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.22227278$$

$$Mu = MRc (4.14) = 8.4307E+008$$

$$u = su (4.1) = 9.3115772E-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of $Mu2+$

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191E-006$$

$$Mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00791261$$

$$\text{we (5.4c) } = 0.01216945$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.45746528$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1) / Aconf,max1) * (Aconf,min1 / Aconf,max1), 0) = 0.45746528$$

The definitions of $AnoConf$, $Aconf,min$ and $Aconf,max$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$Aconf,max1 = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$Aconf,min1 = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$
 L_{stir1} (Length of stirrups along Y) = 2060.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$
 L_{stir2} (Length of stirrups along Y) = 1468.00
 A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$
 L_{stir1} (Length of stirrups along X) = 2060.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$
 L_{stir2} (Length of stirrups along X) = 1468.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu1_{nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_1 = fs_1/1.2$, 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 $fs_1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9484$

with $Es_1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2_nominal} ((5.5), TBDY) = 0.032$$

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.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s1,com,jacket} + f_{s,core} * A_{s1,com,core}) / A_{s1,com} = 368.7326$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s1,com,jacket} + E_{s,core} * A_{s1,com,core}) / A_{s1,com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$$

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.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s1,mid,jacket} + f_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 359.9093$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s1,mid,jacket} + E_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 200000.00$$

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.02391392$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.04978341$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.02714524$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.05651029$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.14856848$$

$$M_u = M_{Rc} (4.14) = 5.0139E+008$$

$$u = s_u (4.1) = 8.5055191E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$M_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of $A_{noConf1}$, $A_{conf,min1}$ and $A_{conf,max1}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 442.4791$$

$$fy_1 = 368.7326$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389

2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859

v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265

2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886

v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.22227278

Mu = MRc (4.14) = 8.4307E+008

u = su (4.1) = 9.3115772E-006

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l V_{Col0}$

$V_{Col0} = 998297.143$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f^* V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} \text{Area}_{jacket} + f_c'_{core} \text{Area}_{core}) / \text{Area}_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.5735$

$V_u = 0.0005439$

$d = 0.8h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$ is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

$s/d = 0.3125$

$V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$s/d = 0.16666667$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$ is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

$s/d = 0.56818182$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l V_{Col0}$

$V_{Col0} = 998297.143$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f^* V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.5741$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$ is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

$s/d = 0.3125$

$V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$s/d = 0.16666667$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$ is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

$s/d = 0.56818182$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$b_w = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjlc

Constant Properties

Knowledge Factor, $\phi = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 400.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 No FRP Wrapping

 Stepwise Properties

Bending Moment, $M = -1.9722E+007$
 Shear Force, $V_2 = -6543.324$
 Shear Force, $V_3 = 93.37449$
 Axial Force, $F = -16953.648$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 5969.026$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1137.257$
 -Compression: $A_{sl,com} = 2362.478$
 -Middle: $A_{sl,mid} = 2469.292$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten,jacket} = 829.3805$
 -Compression: $A_{sl,com,jacket} = 1746.726$
 -Middle: $A_{sl,mid,jacket} = 1545.664$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten,core} = 307.8761$
 -Compression: $A_{sl,com,core} = 615.7522$
 -Middle: $A_{sl,mid,core} = 923.6282$
 Mean Diameter of Tension Reinforcement, $DbL = 16.80$

 Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.041534$
 $u = y + p = 0.041534$

 - Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00256158$ ((4.29), Biskinis Phd))
 $M_y = 3.6946E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3014.111
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$
 factor = 0.30
 $A_g = 440000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$
 $N = 16953.648$
 $E_c * I_g = E_c_{jacket} * I_g_{jacket} + E_c_{core} * I_g_{core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$

web width, $b_w = 400.00$

flange thickness, $t = 400.00$

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 2.5827092\text{E-}006$$

$$\text{with } ((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 291.9465$$

$$d = 707.00$$

$$y = 0.2005739$$

$$A = 0.01136652$$

$$B = 0.00499529$$

$$\text{with } p_t = 0.00434791$$

$$p_c = 0.0044554$$

$$p_v = 0.00465684$$

$$N = 16953.648$$

$$b = 750.00$$

$$" = 0.06082037$$

$$y_{\text{comp}} = 1.5663957\text{E-}005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.19866014$$

$$A = 0.01118434$$

$$B = 0.00488577$$

$$\text{with } E_s = 200000.00$$

CONFIRMATION: $y = 0.19956922 < t/d$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.03897242$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/d < 1$

$$\text{shear control ratio } V_y E / V_{CoI} O E = 0.56300412$$

$$d = d_{\text{external}} = 707.00$$

$$s = s_{\text{external}} = 0.00$$

$$- t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00434791$$

$$\text{jacket: } s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00367709$$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2060.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00067082$$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$N_{UD} = 16953.648$$

$$A_g = 440000.00$$

$$f_c E = (f_c \cdot \text{Area}_{\text{jacket}} + f_c \cdot \text{Area}_{\text{core}}) / \text{section_area} = 27.68182$$

$$f_y E = (f_y \cdot \text{ext_Long_Reinf} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_y \cdot \text{int_Long_Reinf} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 521.1696$$

$$f_y E = (f_y \cdot \text{ext_Trans_Reinf} \cdot s_1 + f_y \cdot \text{int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$$

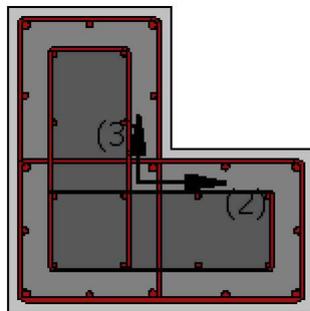
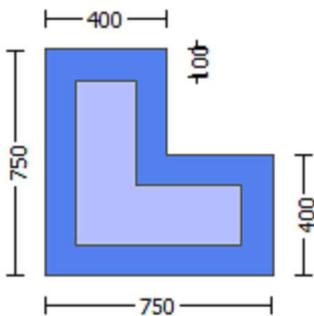
$$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.011257$$

b = 750.00
d = 707.00
f_{cE} = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity VR_d
Edge: End
Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjlc

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of 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, $f_s = f_{sm} = 444.4444$

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 400.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.9722E+007$
Shear Force, $V_a = -6543.324$
EDGE -B-
Bending Moment, $M_b = 87505.349$
Shear Force, $V_b = 6543.324$
BOTH EDGES
Axial Force, $F = -16953.648$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl} = 0.00$
-Compression: $A_{slc} = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1137.257$
-Compression: $A_{sl,com} = 2362.478$
-Middle: $A_{sl,mid} = 2469.292$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 1.0165E+006$
 V_n ((10.3), ASCE 41-17) = $k_n l V_{CoI} = 1.0165E+006$
 $V_{CoI} = 1.0165E+006$
 $k_n l = 1.00$
displacement_ductility_demand = 0.08075324

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + \phi \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 21.31818$, but $f'_c^{0.5} \leq$
8.3 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 87505.349$
 $V_u = 6543.324$

$d = 0.8 \cdot h = 600.00$
 $Nu = 16953.648$
 $Ag = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 793340.11$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$
 $V_{s,j1} = 251327.412$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 471238.898$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 70773.799$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 736127.561$
 $bw = 400.00$

displacement ductility demand is calculated as ϕ / y

- Calculation of ϕ / y for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation $= 2.0588749E-005$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00025496$ ((4.29), Biskinis Phd))
 $M_y = 3.6946E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.4491E+014$
 $factor = 0.30$
 $Ag = 440000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$
 $N = 16953.648$
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ / y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$
 web width, $bw = 400.00$
 flange thickness, $t = 400.00$

y = Min(y_ten, y_com)
y_ten = 2.5827092E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/d)^ 2/3) = 291.9465
d = 707.00
y = 0.2005739
A = 0.01136652
B = 0.00499529
with pt = 0.00214476
pc = 0.0044554
pv = 0.00465684
N = 16953.648
b = 750.00
" = 0.06082037
y_comp = 1.5663957E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866014
A = 0.01118434
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19956922 < t/d

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

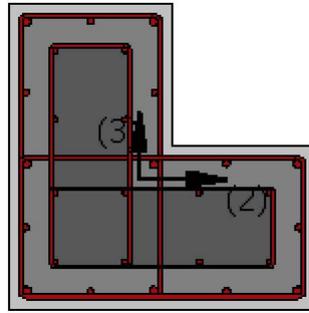
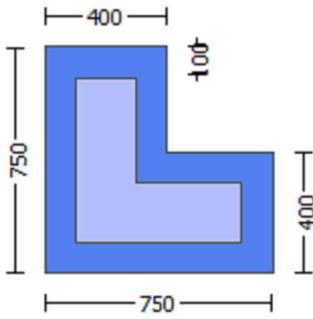
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$

Existing Column
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
 Existing Column
 Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 400.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00
 Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -0.0005439$
 EDGE -B-
 Shear Force, $V_b = 0.0005439$

BOTH EDGES

Axial Force, $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{,ten} = 1137.257$

-Compression: $As_{,com} = 2362.478$

-Middle: $As_{,mid} = 2469.292$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$

$M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$

$M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

$\omega (5A.5, TBDY) = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00791261$

$\omega_e (5.4c) = 0.01216945$

$\omega_{ase} ((5.4d), TBDY) = (\omega_{ase1} * A_{ext} + \omega_{ase2} * A_{int}) / A_{sec} = 0.45746528$

$\omega_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\omega_{ase2} (>= \omega_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su1 = 0.4 * esu1_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_s,jacket * A_{sl,ten,jacket} + f_s,core * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with $Es1 = (E_s,jacket * A_{sl,ten,jacket} + E_s,core * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su2 = 0.4 * esu2_{nominal}$ ((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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (f_s,jacket * A_{sl,com,jacket} + f_s,core * A_{sl,com,core}) / A_{sl,com} = 368.7326$

with $Es2 = (E_s,jacket * A_{sl,com,jacket} + E_s,core * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14856848

Mu = MRc (4.14) = 5.0139E+008

u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00174912

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00791261

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1) * (Aconf,min1/Aconf,max1), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.92621$$

Expression (5.4d) for psh,min * Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fsjacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 368.7326$$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{ou,min} = lb/lb_{,min} = 0.30$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2 / 1.2$, 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 $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 367.9484$
 with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $yv = 0.00140044$
 $shv = 0.0044814$
 $ftv = 431.8911$
 $fyv = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{ou,min} = lb/ld = 0.30$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv / 1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv / 1.2$, from table 5.1, TBDY.
 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 $fsv = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 359.9093$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.093334389$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483859$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.09522963$
 and confined core properties:
 $b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.11468265$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508886$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.11699947$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22227278$
 $Mu = MRc (4.14) = 8.4307E+008$
 $u = su (4.1) = 9.3115772E-006$

 Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Mu_{2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191E-006$$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\omega (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00791261$$

$$\omega_e (5.4c) = 0.01216945$$

$$\text{ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.45746528}$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{ase2} (>= \text{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.538$$

$$fy1 = 367.9484$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 367.9484$$

$$\text{with } Es1 = (Es_jacket * Asl,ten,jacket + Es_core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 442.4791$$

$$fy2 = 368.7326$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 368.7326$$

$$\text{with } Es2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 431.8911$$

$$fyv = 359.9093$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 359.9093$$

$$\text{with } Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.02391392$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.04978341$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.02714524$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.05651029$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.14856848$$

$$\mu_u = M_{Rc}(4.14) = 5.0139E+008$$

$$u = s_u(4.1) = 8.5055191E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\alpha(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_u = 0.00791261$$

$$w_e(5.4c) = 0.01216945$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1}(\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$p_{sh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.92621
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00367709
Lstir₁ (Length of stirrups along X) = 2060.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00067082
Lstir₂ (Length of stirrups along X) = 1468.00
Astir₂ (stirrups area) = 50.26548

Asec = 440000.00
s₁ = 100.00
s₂ = 250.00

fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y₁ = 0.00140044
sh₁ = 0.0044814
ft₁ = 442.4791
fy₁ = 368.7326
su₁ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 0.30

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} = 368.7326

with Es₁ = (Es_{jacket}*Asl_{ten,jacket} + Es_{core}*Asl_{ten,core})/Asl_{ten} = 200000.00

y₂ = 0.00140044
sh₂ = 0.0044814

ft₂ = 441.538
fy₂ = 367.9484

su₂ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_{b,min} = 0.30

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} = 367.9484

with Es₂ = (Es_{jacket}*Asl_{com,jacket} + Es_{core}*Asl_{com,core})/Asl_{com} = 200000.00

y_v = 0.00140044
sh_v = 0.0044814

ft_v = 431.8911
fy_v = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 0.30

suv = 0.4*esuv_{nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_{nominal} = 0.08,

considering characteristic value 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/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fsv = (fs_{jacket}*Asl_{mid,jacket} + fs_{mid}*Asl_{mid,core})/Asl_{mid} = 359.9093

$$\text{with } E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09334389$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483859$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.11468265$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508886$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$M_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 998297.143$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

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: $f'_c = (f'_c \cdot A_{jacket} + f'_c \cdot A_{core}) / A_{section} = 27.68182$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$M_u = 326.4029$$

$$V_u = 0.0005439$$

$$d = 0.8 \cdot h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

where:

$$V_{s,jacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col,j1 = 1.00$

$$s/d = 0.16666667$$

$V_{sj2} = 279252.68$ is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col,j2 = 1.00$

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$

$$s/d = 1.5625$$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

$$bw = 400.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$$V_{Col0} = 998297.143$$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 326.4024$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

$$s/d = 0.16666667$$

$V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

V_{s,c2} is multiplied by Col,c2 = 0.00
s/d = 1.5625
V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: V_s + V_f <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjls

Constant Properties

Knowledge Factor, γ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$
#####

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 400.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -0.0005439$
EDGE -B-
Shear Force, $V_b = 0.0005439$
BOTH EDGES
Axial Force, $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1137.257$

-Compression: $A_{sc,com} = 2362.478$

-Middle: $A_{st,mid} = 2469.292$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$

$M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$

$M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

ω (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00791261$

ω_e (5.4c) = 0.01216945

ω_{se} ((5.4d), TBDY) = $(\omega_{se1} * A_{ext} + \omega_{se2} * A_{int}) / A_{sec} = 0.45746528$

$\omega_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\omega_{se2} (>= \omega_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with $Es_1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 * esu_{2,nominal}$ ((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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$

with $Es_2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

ftv = 431.8911
fyv = 359.9093
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lo,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14856848

Mu = MRc (4.14) = 5.0139E+008

u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00174912

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00791261

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528

ase1 = Max(((Aconf,max1 - AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

Expression (5.4d) for $psh_{min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$

and also multiplied by the $shear_factor$ according to 15.7.1.4, with

$Shear_factor = 1.00$

$lo/lo_{u,min} = l_b/l_d = 0.30$

$su1 = 0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered

characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 368.7326$

with $Es1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.00140044$

$sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{min} = lb/lb_{min} = 0.30$
 $su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2_nominal} = 0.08$,
 For calculation of $esu_{2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9484$
 with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $yv = 0.00140044$
 $shv = 0.0044814$
 $ftv = 431.8911$
 $fyv = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$
 with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09334389$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04483859$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.09522963$
 and confined core properties:
 $b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.11468265$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05508886$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.11699947$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22227278$
 $Mu = MRc (4.14) = 8.4307E+008$
 $u = su (4.1) = 9.3115772E-006$

 Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.5055191E-006$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\alpha (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \alpha) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From (5.A5), TBDY: } \alpha = 0.002$$

$$c = \text{confinement factor} = 1.00$$

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4*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 = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044
sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044
shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392

2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341

v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524

2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029

v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

$$\begin{aligned} su(4.9) &= 0.14856848 \\ \mu &= MRc(4.14) = 5.0139E+008 \\ u &= su(4.1) = 8.5055191E-006 \end{aligned}$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_2

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\begin{aligned} u &= 9.3115772E-006 \\ \mu &= 8.4307E+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 400.00 \\ d &= 707.00 \\ d' &= 43.00 \\ v &= 0.00174912 \\ N &= 16323.501 \\ f_c &= 33.00 \end{aligned}$$

α (5A.5, TBDY) = 0.002

Final value of μ : $\mu^* = \text{shear_factor} * \text{Max}(\mu, \alpha) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu = 0.00791261$

ω (5.4c) = 0.01216945

α_{se} ((5.4d), TBDY) = $(\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.45746528$

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\alpha_{se2} (> \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.92621
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00367709
Lstir₁ (Length of stirrups along X) = 2060.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00067082
Lstir₂ (Length of stirrups along X) = 1468.00
Astir₂ (stirrups area) = 50.26548

Asec = 440000.00
s₁ = 100.00
s₂ = 250.00

fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y₁ = 0.00140044
sh₁ = 0.0044814
ft₁ = 442.4791
fy₁ = 368.7326
su₁ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

su₁ = 0.4*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 = 368.7326

with Es₁ = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y₂ = 0.00140044
sh₂ = 0.0044814

ft₂ = 441.538
fy₂ = 367.9484

su₂ = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su₂ = 0.4*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 = 367.9484

with Es₂ = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

y_v = 0.00140044
sh_v = 0.0044814

ft_v = 431.8911
fy_v = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and y_v, sh_v,ft_v,fy_v, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs₁/fc) = 0.09334389

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.04483859$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$M_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 998297.143$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$M_u = 326.5735$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

where:

$$V_{s,jacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 279252.68$ is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col,j1 = 1.00$

$$s/d = 0.3125$$

$V_{sj2} = 523598.776$ is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col,j2 = 1.00$

$$s/d = 0.16666667$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$
 $V_{Col0} = 998297.143$
 $k_{nl} = 1$ (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: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 4.00$
 $M_u = 326.5741$
 $V_u = 0.0005439$
 $d = 0.8 * h = 600.00$
 $N_u = 16323.501$
 $Ag = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$

Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 400.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -84132.56$
Shear Force, $V_2 = 6543.324$
Shear Force, $V_3 = -93.37449$
Axial Force, $F = -16953.648$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 2362.478$
-Middle: $As_{mid} = 2469.292$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 829.3805$
-Compression: $As_{c,com,jacket} = 1746.726$
-Middle: $As_{mid,jacket} = 1545.664$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $A_{sl,com,core} = 615.7522$

-Middle: $A_{sl,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = u = 0.03973817$
 $u = y + p = 0.03973817$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00076575$ ((4.29), Biskinis Phd))

$M_y = 3.6946E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 901.023

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$

factor = 0.30

$A_g = 440000.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$

$N = 16953.648$

$E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$

web width, $b_w = 400.00$

flange thickness, $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 2.5827092E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.2005739$

$A = 0.01136652$

$B = 0.00499529$

with $pt = 0.00434791$

$pc = 0.0044554$

$pv = 0.00465684$

$N = 16953.648$

$b = 750.00$

$" = 0.06082037$

$y_{comp} = 1.5663957E-005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866014$

$A = 0.01118434$

$B = 0.00488577$

with $E_s = 200000.00$

CONFIRMATION: $y = 0.19956922 < t/d$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.03897242$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{CoI} O E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$

jacket: $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00367709$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2060.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00067082$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$N_{UD} = 16953.648$

$A_g = 440000.00$

$f_{cE} = (f_{c_jacket} * Area_jacket + f_{c_core} * Area_core) / section_area = 27.68182$

$f_{yE} = (f_{y_ext_Long_Reinf} * Area_ext_Long_Reinf + f_{y_int_Long_Reinf} * Area_int_Long_Reinf) / Area_Tot_Long_Rein = 521.1696$

$f_{yE} = (f_{y_ext_Trans_Reinf} * s_1 + f_{y_int_Trans_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$\rho_l = Area_Tot_Long_Rein / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

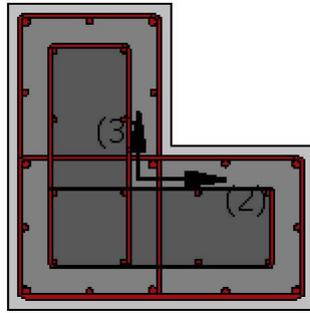
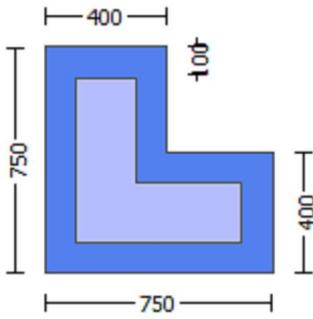
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjlcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $f_s = f_{sm} = 444.4444$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -194177.576$

Shear Force, $V_a = 93.37449$
 EDGE -B-
 Bending Moment, $M_b = -84132.56$
 Shear Force, $V_b = -93.37449$
 BOTH EDGES
 Axial Force, $F = -16953.648$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 5969.026$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1137.257$
 -Compression: $A_{sc,com} = 2362.478$
 -Middle: $A_{sc,mid} = 2469.292$
 Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 1.0165E+006$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 1.0165E+006$
 $V_{CoI} = 1.0165E+006$
 $k_n = 1.00$
 $displacement_ductility_demand = 4.1282056E-005$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + \phi \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$\phi = 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 21.31818$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$
 $M_u = 84132.56$
 $V_u = 93.37449$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16953.648$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 793340.11$
 where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$
 $V_{s,j1} = 471238.898$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$

$V_{s,j1}$ is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 251327.412$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$

$V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 70773.799$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$

$V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$

s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 736127.561
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 = 3.1611559E-008
y = (My*Ls/3)/Eleff = 0.00076575 ((4.29),Biskinis Phd))
My = 3.6946E+008
Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 901.023
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16953.648
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+014

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

Assuming neutral axis within flange (y < t/d, compression zone rectangular) with:
flange width, b = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

y = Min(y_ten, y_com)
y_ten = 2.5827092E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/d)^ 2/3) = 291.9465
d = 707.00
y = 0.2005739
A = 0.01136652
B = 0.00499529
with pt = 0.00214476
pc = 0.0044554
pv = 0.00465684
N = 16953.648
b = 750.00
" = 0.06082037
y_comp = 1.5663957E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866014
A = 0.01118434
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19956922 < t/d

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

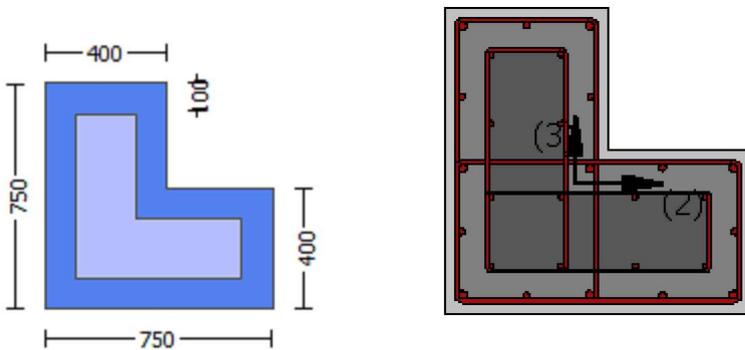
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjlc

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.0005439
EDGE -B-
Shear Force, Vb = 0.0005439
BOTH EDGES
Axial Force, F = -16323.501
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Asl,t = 0.00
-Compression: Asl,c = 5969.026
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2362.478
-Middle: Asl,mid = 2469.292

Calculation of Shear Capacity ratio , $V_e/V_r = 0.56300412$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 8.4307E+008$
 $Mu_{1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $Mu_{1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 8.4307E+008$
 $Mu_{2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $Mu_{2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.5055191E-006$
 $Mu = 5.0139E+008$

with full section properties:

b = 750.00
d = 707.00
d' = 43.00
v = 0.00093286
N = 16323.501
fc = 33.00

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.538$$

$$fy1 = 367.9484$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou,min} = l_b / l_d = 0.30$$

$$su_1 = 0.4 * esu_{1_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{1_nominal} = 0.08$,

For calculation of $esu_{1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 367.9484$$

$$\text{with } Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 442.4791$$

$$fy_2 = 368.7326$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/lb_{min} = 0.30$$

$$su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2_nominal} = 0.08$,

For calculation of $esu_{2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 368.7326$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 431.8911$$

$$fy_v = 359.9093$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$$

$$\text{with } Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.02391392$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04978341$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05078914$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.02714524$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05651029$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05765191$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.14856848$$

$$Mu = MRc (4.14) = 5.0139E+008$$

$$u = su (4.1) = 8.5055191E-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu1-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 9.3115772E-006$$

$$\mu = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

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$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$A_{sec} = 440000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $fy_{we1} = 694.4444$
 $fy_{we2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00140044$
 $sh_1 = 0.0044814$
 $ft_1 = 442.4791$
 $fy_1 = 368.7326$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 0.30$
 $su_1 = 0.4 * esu_1_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1_{nominal} = 0.08$,
 For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * A_{sl, ten, jacket} + fs_{core} * A_{sl, ten, core}) / A_{sl, ten} = 368.7326$
 with $Es_1 = (Es_{jacket} * A_{sl, ten, jacket} + Es_{core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 0.30$
 $su_2 = 0.4 * esu_2_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2_{nominal} = 0.08$,
 For calculation of $esu_2_{nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl, com, jacket} + fs_{core} * A_{sl, com, core}) / A_{sl, com} = 367.9484$
 with $Es_2 = (Es_{jacket} * A_{sl, com, jacket} + Es_{core} * A_{sl, com, core}) / A_{sl, com} = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 431.8911$
 $fy_v = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * A_{sl, mid, jacket} + fs_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 359.9093$
 with $Es_v = (Es_{jacket} * A_{sl, mid, jacket} + Es_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 200000.00$
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.09334389$
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.04483859$
 $v = A_{sl, mid} / (b * d) * (fsv / f_c) = 0.09522963$
 and confined core properties:
 $b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture
satisfies Eq. (4.3)

--->
v < v_{s,y2} - LHS eq.(4.5) is satisfied

$$\text{su (4.9)} = 0.22227278$$

$$\text{Mu} = \text{MRc (4.14)} = 8.4307\text{E}+008$$

$$u = \text{su (4.1)} = 9.3115772\text{E}-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191\text{E}-006$$

$$\text{Mu} = 5.0139\text{E}+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00791261$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00791261$

$$w_e \text{ (5.4c)} = 0.01216945$$

$$ase \text{ ((5.4d), TBDY)} = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max1} = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

A_{conf,min1} = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max1} by a length equal to half the clear spacing between external hoops.

A_{noConf1} = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max2} = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

A_{conf,min2} = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max2} by a length equal to half the clear spacing between internal hoops.

A_{noConf2} = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for p_{sh,min}*F_{ywe} has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044
sh2 = 0.0044814
ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$

with $Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.02391392$

$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.04978341$

$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

$c =$ confinement factor = 1.00

$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.02714524$

$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.05651029$

$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

---->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.14856848

$Mu = MRc$ (4.14) = 5.0139E+008

$u = su$ (4.1) = 8.5055191E-006

Calculation of ratio lb/l_d

Inadequate Lap Length with $lb/l_d = 0.30$

Calculation of $Mu2$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 9.3115772E-006$

$Mu = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174912$

$N = 16323.501$

$fc = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00791261$

we (5.4c) = 0.01216945

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$

$ase1 = Max(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - \text{AnoConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $psh_{,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $psh_{,x} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.92621$
 $psh_1 ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
 $psh_2 ((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

 $psh_{,y} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.92621$
 $psh_1 ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
 $psh_2 ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 368.7326

with Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

$$su_2 = 0.4 * esu_2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs_2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 367.9484$$

$$\text{with } Es_2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 431.8911$$

$$fyv = 359.9093$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou, min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

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.

$$\text{with } fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 359.9093$$

$$\text{with } Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.09334389$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.04483859$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.11468265$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.05508886$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs, y_2$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.22227278$$

$$Mu = MRc (4.14) = 8.4307E+008$$

$$u = su (4.1) = 9.3115772E-006$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $Vr = \text{Min}(Vr_1, Vr_2) = 998297.143$

Calculation of Shear Strength at edge 1, $Vr_1 = 998297.143$

$$Vr_1 = VCol ((10.3), ASCE 41-17) = knl * VColO$$

$$VColO = 998297.143$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = Av * fy * d / s$ ' 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: $fc' = (fc'_jacket * Area_jacket + fc'_core * Area_core) / Area_section = 27.68182$, but $fc'^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$
 $\mu_u = 326.4029$
 $\nu_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 881489.011$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 279252.68$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $b_w = 400.00$

 Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 998297.143$
 $knl = 1$ (zero step-static loading)

 NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$
 $\mu_u = 326.4024$
 $\nu_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 881489.011$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$

$s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 279252.68$ is calculated for section flange jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.3125$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.5625$
 $V_f((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcjlc

Constant Properties

 Knowledge Factor, $= 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
 Existing Column
 Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -0.0005439$
EDGE -B-
Shear Force, $V_b = 0.0005439$
BOTH EDGES
Axial Force, $F = -16323.501$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1137.257$
-Compression: $A_{sc,com} = 2362.478$
-Middle: $A_{st,mid} = 2469.292$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56300412$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.4307E+008$
 $M_{u1+} = 5.0139E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $M_{u1-} = 8.4307E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.4307E+008$
 $M_{u2+} = 5.0139E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $M_{u2-} = 8.4307E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.5055191E-006$
 $M_u = 5.0139E+008$

with full section properties:

$b = 750.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093286$
 $N = 16323.501$
 $f_c = 33.00$
 ϕ_o (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.00791261$

w_e (5.4c) = 0.01216945

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.002$

c = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 0.30$

$su1 = 0.4 * e_{su1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $e_{su1_nominal} = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 367.9484$

with $Es1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lo_{ou,min} = lb/lb_{,min} = 0.30$

$su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 368.7326$

with $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 431.8911$

$fyv = 359.9093$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lo_{ou,min} = lb/ld = 0.30$

$suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs_{y2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14856848$

$Mu = MRc (4.14) = 5.0139E+008$

$u = su (4.1) = 8.5055191E-006$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu1-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$\text{Mu} = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e (5.4c) = 0.01216945$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh,min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$s_2 = 250.00$
 $fy_{we1} = 694.4444$
 $fy_{we2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00140044$
 $sh_1 = 0.0044814$
 $ft_1 = 442.4791$
 $fy_1 = 368.7326$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$
 with $Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 441.538$
 $fy_2 = 367.9484$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9484$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 431.8911$
 $fy_v = 359.9093$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.09334389$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.04483859$
 $v = A_{sl,mid} / (b * d) * (fs_v / f_c) = 0.09522963$
 and confined core properties:
 $b = 340.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.11468265$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.05508886$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture
satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$$s_u(4.9) = 0.22227278$$

$$M_u = M_{Rc}(4.14) = 8.4307E+008$$

$$u = s_u(4.1) = 9.3115772E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191E-006$$

$$M_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\omega(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \omega: \omega^* = \text{shear_factor} \cdot \text{Max}(\omega, \omega_c) = 0.00791261$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \omega_c = 0.00791261$$

$$\omega_e(5.4c) = 0.01216945$$

$$a_{se}(5.4d, TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf, max1} - A_{noConf1}) / A_{conf, max1}) \cdot (A_{conf, min1} / A_{conf, max1}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf, min}$ and $A_{conf, max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf, max1} = 353600.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf, min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf, max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf, max2} - A_{noConf2}) / A_{conf, max2}) \cdot (A_{conf, min2} / A_{conf, max2}), 0) = 0.45746528$$

The definitions of A_{noConf} , $A_{conf, min}$ and $A_{conf, max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf, max2} = 171264.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf, min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf, max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh, min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 2.92621$$

Expression (5.4d) for $p_{sh, min} \cdot F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 2.92621$$

psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621
psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = $0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$

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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = $(f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with Es1 = $(E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = $0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = $(f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$

with Es2 = $(E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = $0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of $\epsilon_{sv_nominal}$ and γ_v , γ_{sh} , γ_{ftv} , γ_{fyv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , γ_{sh1} , γ_{ft1} , γ_{fy1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 359.9093$

with $\epsilon_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$\gamma_1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02391392$

$\gamma_2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04978341$

$\gamma_v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$\gamma_1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.02714524$

$\gamma_2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05651029$

$\gamma_v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$\gamma_v < \gamma_{sv2}$ - LHS eq.(4.5) is satisfied

--->

$\mu_u (4.9) = 0.14856848$

$\mu_u = MR_c (4.14) = 5.0139E+008$

$u = \mu_u (4.1) = 8.5055191E-006$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$u = 9.3115772E-006$

$\mu_u = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$\gamma_v = 0.00174912$

$N = 16323.501$

$f_c = 33.00$

$cc (5A.5, TBDY) = 0.002$

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.00791261$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_u = 0.00791261$

$w_e (5.4c) = 0.01216945$

$a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.92621$$

Expression (5.4d) for $psh,min * Fywe$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c =$ confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/l_d = 0.30$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 368.7326$$

$$\text{with } Es1 = (Es_jacket * Asl,ten,jacket + Es_core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/l_b,min = 0.30$$

$$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$

with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 431.8911$

$fy_v = 359.9093$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.30$

$suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fsv/1.2$, 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 $fs_{yv} = fsv/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09334389$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483859$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.09522963$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.11468265$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508886$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

su (4.9) = 0.22227278

$\mu_u = MR_c$ (4.14) = 8.4307E+008

$u = su$ (4.1) = 9.3115772E-006

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1, $V_{r1} = 998297.143$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{ColO}$

$V_{ColO} = 998297.143$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.5735$

$V_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 78637.555$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 838832.606$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 998297.143$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I \cdot V_{Col0}$
 $V_{Col0} = 998297.143$
 $k_n I = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $M_u = 326.5741$
 $V_u = 0.0005439$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16323.501$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 881489.011$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$
 $V_{s,j1} = 279252.68$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

s/d = 0.3125

$V_{s,j2} = 523598.776$ is calculated for section flange jacket, with:

d = 600.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 100.00

$V_{s,j2}$ is multiplied by Col,j2 = 1.00

s/d = 0.16666667

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

d = 160.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c1}$ is multiplied by Col,c1 = 0.00

s/d = 1.5625

$V_{s,c2} = 78637.555$ is calculated for section flange core, with:

d = 440.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c2}$ is multiplied by Col,c2 = 1.00

s/d = 0.56818182

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 838832.606$

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjlc

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 400.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 400.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 87505.349$
Shear Force, $V_2 = 6543.324$
Shear Force, $V_3 = -93.37449$
Axial Force, $F = -16953.648$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 5969.026$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 2362.478$
-Middle: $As_{c,mid} = 2469.292$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 829.3805$
-Compression: $As_{c,com,jacket} = 1746.726$
-Middle: $As_{c,mid,jacket} = 1545.664$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 307.8761$
-Compression: $As_{c,com,core} = 615.7522$
-Middle: $As_{c,mid,core} = 923.6282$
Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = * u = 0.03922738$
 $u = y + p = 0.03922738$

- Calculation of y -

 $y = (M_y * L_s / 3) / E_{eff} = 0.00025496$ ((4.29), Biskinis Phd))
 $M_y = 3.6946E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.4491E+014$
 $factor = 0.30$
 $A_g = 440000.00$
Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 27.68182$
 $N = 16953.648$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:
flange width, $b = 750.00$
web width, $b_w = 400.00$
flange thickness, $t = 400.00$

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 2.5827092E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 291.9465$
 $d = 707.00$
 $y = 0.2005739$
 $A = 0.01136652$
 $B = 0.00499529$
with $pt = 0.00434791$
 $pc = 0.0044554$
 $pv = 0.00465684$

$N = 16953.648$
 $b = 750.00$
 $" = 0.06082037$
 $y_{comp} = 1.5663957E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19866014$
 $A = 0.01118434$
 $B = 0.00488577$
 with $E_s = 200000.00$
 CONFIRMATION: $y = 0.19956922 < t/d$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 - Calculation of p -

 From table 10-8: $p = 0.03897242$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{CoI} O E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$

jacket: $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00367709$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2060.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00067082$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$N_{UD} = 16953.648$

$A_g = 440000.00$

$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section_area = 27.68182$

$f_{yIE} = (f_{y,ext_Long_Reinf} * Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} * Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 521.1696$

$f_{yIE} = (f_{y,ext_Trans_Reinf} * s_1 + f_{y,int_Trans_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$p_l = Area_{Tot_Long_Rein} / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

 End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)