

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

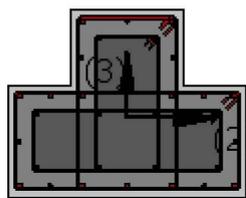
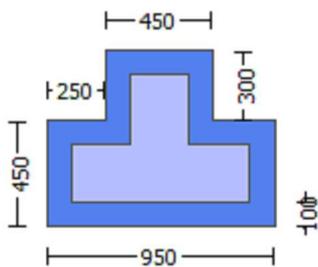
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
 New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
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 Note: Especially for the calculation of μ_y for displacement ductility demand,
 the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
 Deformation-Controlled Action (Table C7-1, ASCE 41-17).
 Jacket
 New material: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 Existing Column
 New material: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 450.00$
 Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $E_{cc} = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{o,min} = l_b/l_d >= 1$)
 No FRP Wrapping

 Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -2.4201E+007$
 Shear Force, $V_a = -7994.629$
 EDGE -B-
 Bending Moment, $M_b = 212176.02$
 Shear Force, $V_b = 7994.629$
 BOTH EDGES
 Axial Force, $F = -21698.244$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1539.38$
 -Compression: $A_{sl,com} = 1539.38$
 -Middle: $A_{sl,mid} = 3612.832$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 1.2171E+006$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Co10} = 1.2171E+006$
 $V_{Co10} = 1.2171E+006$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.01194044$

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

 $= 1$ (normal-weight concrete)

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

$M/Vd = 3.98305$

$\mu_u = 2.4201E+007$

$V_u = 7994.629$

$d = 0.8 \cdot h = 760.00$

$N_u = 21698.244$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s\text{jacket}} + V_{s\text{core}} = 1.0003E+006$

where:

$V_{s\text{jacket}} = V_{s\text{j1}} + V_{s\text{j2}} = 879645.943$

$V_{s\text{j1}} = 282743.339$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s\text{j2}} = 596902.604$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.13157895$

$V_{s\text{core}} = V_{s\text{c1}} + V_{s\text{c2}} = 120637.158$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

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

$s/d = 1.25$

$V_{s\text{c2}} = 120637.158$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1360E+006$

$bw = 450.00$

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 $\theta = 5.1756875E-005$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00433459$ ((4.29), Biskinis Phd)

$M_y = 1.1980E+009$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3027.121

From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 2.7887E+014$

factor = 0.30

$A_g = 562500.00$

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

$N = 21698.244$

$E_c \cdot I_g = E_{c\text{jacket}} \cdot I_{g\text{jacket}} + E_{c\text{core}} \cdot I_{g\text{core}} = 9.2958E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

y = Min(y_ten, y_com)
y_ten = 4.1203973E-006
with fy = 555.56
d = 907.00
y = 0.25671634
A = 0.01649063
B = 0.00868179
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21698.244
b = 450.00
" = 0.04740904
y_comp = 9.4777787E-006
with fc = 33.00
Ec = 26999.444
y = 0.25592798
A = 0.01627411
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 2

column C1, Floor 1

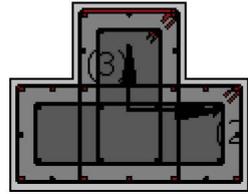
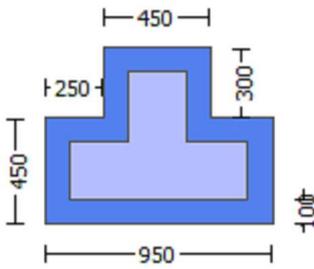
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

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

Constant Properties

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

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

Existing Column

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -2.5090294E-020$

EDGE -B-

Shear Force, $V_b = 2.5090294E-020$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1539.38$

-Compression: $As_{c,com} = 2475.575$

-Middle: $As_{c,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.03465$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.0610E+009$

$Mu_{1+} = 1.9075E+009$, 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

$Mu_{1-} = 2.0610E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.0610E+009$

$Mu_{2+} = 1.9075E+009$, 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

$Mu_{2-} = 2.0610E+009$, 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:

$\phi_u = 5.2259729E-005$

$Mu = 1.9075E+009$

with full section properties:

$b = 950.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093808$

$N = 20792.022$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$

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

From (5.4b), TBDY: $\phi_u = 0.01151713$

$\omega_e (5.4c) = 0.04017143$

$\omega_{ase} ((5.4d), TBDY) = (\omega_{ase1} * A_{ext} + \omega_{ase2} * A_{int}) / A_{sec} = 0.53375773$

$\omega_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\omega_{ase2} (>= \omega_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 2.48363$

 $psh_{,x} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.48363$
 psh_1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 psh_2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

 $psh_{,y} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.97078$
 psh_1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 psh_2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$
From ((5.A5), TBDY), TBDY: $cc = 0.00424426$
 $c = \text{confinement factor} = 1.22443$

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

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

$lo/lo_{,min} = lb/ld = 1.00$
 $su_1 = 0.4 * esu_{1,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

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

with $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

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

$y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$

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

$lo/lo_{,min} = lb/lb_{,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

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

$yv = 0.0025$

$shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$
 with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636$

and confined core properties:

$b = 890.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$v < vs,c$ - RHS eq.(4.5) is satisfied

$su (4.8) = 0.13390923$

$Mu = MRc (4.15) = 1.9075E+009$

$u = su (4.1) = 5.2259729E-005$

Calculation of ratio lb/ld

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

Calculation of $Mu1$ -

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

$u = 6.5076774E-005$

$Mu = 2.0610E+009$

with full section properties:

$b = 450.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00198039$

$N = 20792.022$

$fc = 33.00$

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

Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01151713$

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

From (5.4b), TBDY: $cu = 0.01151713$

$we (5.4c) = 0.04017143$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{,min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$$

$$psh1((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$$

$$psh1((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

$$lo/lou_{,min} = lb/d = 1.00$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619

2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187

v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537

and confined core properties:

b = 390.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.19731035

2 = Asl,com/(b*d)*(fs2/fc) = 0.12269298

v = Asl,mid/(b*d)*(fsv/fc) = 0.21333555

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.8) = 0.30448812

Mu = MRc (4.15) = 2.0610E+009

u = su (4.1) = 6.5076774E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

$$u = 5.2259729E-005$$

$$Mu = 1.9075E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\phi_{we} \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ (5.4d), TBDY} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ (5.4d), TBDY} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ (5.4d), TBDY} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ (5.4d), TBDY} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424426$$

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141

2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398

v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636

and confined core properties:

b = 890.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434

2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184

v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$$s_u(4.8) = 0.13390923$$

$$\mu_u = M_{Rc}(4.15) = 1.9075E+009$$

$$u = s_u(4.1) = 5.2259729E-005$$

Calculation of ratio l_b/l_d

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

Calculation of μ_u

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

$$u = 6.5076774E-005$$

$$\mu_u = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01151713$$

$$w_e(5.4c) = 0.04017143$$

$$a_{se}(5.4d, TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1}(5.4d, TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1}(\text{Length of stirrups along Y}) = 2160.00$$

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

$$p_{sh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2}(\text{Length of stirrups along Y}) = 1568.00$$

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

$$\text{psh}_y * \text{Fywe} = \text{psh}_1 * \text{Fywe}_1 + \text{ps}_2 * \text{Fywe}_2 = 2.97078$$

$$\text{psh}_1 ((5.4d), \text{TBDY}) = \text{Lstir}_1 * \text{Astir}_1 / (\text{Asec} * \text{s}_1) = 0.00357443$$

$$\text{Lstir}_1 (\text{Length of stirrups along X}) = 2560.00$$

$$\text{Astir}_1 (\text{stirrups area}) = 78.53982$$

$$\text{psh}_2 ((5.4d), \text{TBDY}) = \text{Lstir}_2 * \text{Astir}_2 / (\text{Asec} * \text{s}_2) = 0.00070345$$

$$\text{Lstir}_2 (\text{Length of stirrups along X}) = 1968.00$$

$$\text{Astir}_2 (\text{stirrups area}) = 50.26548$$

$$\text{Asec} = 562500.00$$

$$\text{s}_1 = 100.00$$

$$\text{s}_2 = 250.00$$

$$\text{fywe}_1 = 694.45$$

$$\text{fywe}_2 = 694.45$$

$$\text{fce} = 33.00$$

$$\text{From } ((5.A5), \text{TBDY}), \text{TBDY: } \text{cc} = 0.00424426$$

$$\text{c} = \text{confinement factor} = 1.22443$$

$$\text{y}_1 = 0.0025$$

$$\text{sh}_1 = 0.008$$

$$\text{ft}_1 = 833.34$$

$$\text{fy}_1 = 694.45$$

$$\text{su}_1 = 0.032$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 1.00$$

$$\text{su}_1 = 0.4 * \text{esu}_1\text{nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } \text{esu}_1\text{nominal} = 0.08,$$

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

$$\text{y}_1, \text{sh}_1, \text{ft}_1, \text{fy}_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } \text{fs}_1 = (\text{fs,jacket} * \text{Asl,ten,jacket} + \text{fs,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 694.45$$

$$\text{with } \text{Es}_1 = (\text{Es,jacket} * \text{Asl,ten,jacket} + \text{Es,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 200000.00$$

$$\text{y}_2 = 0.0025$$

$$\text{sh}_2 = 0.008$$

$$\text{ft}_2 = 833.34$$

$$\text{fy}_2 = 694.45$$

$$\text{su}_2 = 0.032$$

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

$$\text{lo/lou,min} = \text{lb/lb,min} = 1.00$$

$$\text{su}_2 = 0.4 * \text{esu}_2\text{nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } \text{esu}_2\text{nominal} = 0.08,$$

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

$$\text{y}_2, \text{sh}_2, \text{ft}_2, \text{fy}_2, \text{ are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } \text{fs}_2 = (\text{fs,jacket} * \text{Asl,com,jacket} + \text{fs,core} * \text{Asl,com,core}) / \text{Asl,com} = 694.45$$

$$\text{with } \text{Es}_2 = (\text{Es,jacket} * \text{Asl,com,jacket} + \text{Es,core} * \text{Asl,com,core}) / \text{Asl,com} = 200000.00$$

$$\text{y}_v = 0.0025$$

$$\text{sh}_v = 0.008$$

$$\text{ft}_v = 833.34$$

$$\text{fy}_v = 694.45$$

$$\text{suv} = 0.032$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 1.00$$

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

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

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.

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.16374619$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10182187$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17704537$$

and confined core properties:

$$b = 390.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19731035$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12269298$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21333555$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$$s_u (4.8) = 0.30448812$$

$$M_u = M_{Rc} (4.15) = 2.0610E+009$$

$$u = s_u (4.1) = 6.5076774E-005$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.3280E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.3280E+006$

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

$$V_{Col0} = 1.3280E+006$$

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

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

$$M/Vd = 2.00$$

$$M_u = 1534.018$$

$$V_u = 2.5090294E-020$$

$$d = 0.8 * h = 600.00$$

$$N_u = 20792.022$$

$$A_g = 337500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 936062.473$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$$

$V_{s,j1} = 523602.964$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

$V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 0.56818182$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.25$$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280E+006$

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

$$V_{Col0} = 1.3280E+006$$

$knl = 1$ (zero step-static loading)

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\mu_u = 1534.018$$

$$V_u = 2.5090294E-020$$

$$d = 0.8 * h = 600.00$$

$$N_u = 20792.022$$

$$A_g = 337500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 936062.473$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$$

$V_{s,j1} = 523602.964$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

$V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 0.56818182$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

s = 250.00
Vs,c2 is multiplied by Col,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 1.0304E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

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

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

Existing Column

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.5362867E-036$

EDGE -B-

Shear Force, $V_b = -1.5362867E-036$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{ten} = 1539.38$

-Compression: $As_{com} = 1539.38$

-Middle: $As_{mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.0549$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6949E+006$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.5424E+009$

$Mu_{1+} = 2.5424E+009$, 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

$Mu_{1-} = 2.5424E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.5424E+009$

$Mu_{2+} = 2.5424E+009$, 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

$Mu_{2-} = 2.5424E+009$, 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:

$\phi_u = 4.7487455E-005$

$M_u = 2.5424E+009$

with full section properties:

$b = 450.00$

$d = 907.00$

$d' = 43.00$

$v = 0.0015437$

$N = 20792.022$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$

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

From (5.4b), TBDY: $\phi_u = 0.01151713$

$\omega_e (5.4c) = 0.04017143$

$\omega_{ase} ((5.4d), TBDY) = (\omega_{ase1} * A_{ext} + \omega_{ase2} * A_{int}) / A_{sec} = 0.53375773$

$\omega_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\omega_{ase2} (>= \omega_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$

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

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$
 $c = \text{confinement factor} = 1.22443$

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

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

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

$su1 = 0.4 * esu1_{nominal}$ ((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 $fs1 = (f_s,jacket * A_{sl,ten,jacket} + f_s,core * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

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

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

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

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

$su2 = 0.4 * esu2_{nominal}$ ((5.5), TBDY) = 0.032

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

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

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

with $fs2 = (f_s,jacket * A_{sl,com,jacket} + f_s,core * A_{sl,com,core}) / A_{sl,com} = 694.45$

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

$yv = 0.0025$
 $shv = 0.008$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.07936942$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.07936942$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.09471283$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.09471283$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$v < vs_c$ - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.2570428$$

$$Mu = MRc (4.15) = 2.5424E+009$$

$$u = su (4.1) = 4.7487455E-005$$

Calculation of ratio lb/ld

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

Calculation of $Mu1$ -

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

$$u = 4.7487455E-005$$

$$Mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01151713$$

$$we (5.4c) = 0.04017143$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1) * (Aconf,min1/Aconf,max1), 0) = 0.53375773$$

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 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (\geq ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.53375773$$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.48363$$

$$psh,x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.48363$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$psh,y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2560.00$$

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

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1968.00$$

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

$$Asec = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

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

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

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

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

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

$$y2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07936942$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07936942$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09471283$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.09471283$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$$su (4.8) = 0.2570428$$

$$Mu = MRc (4.15) = 2.5424E+009$$

$$u = su (4.1) = 4.7487455E-005$$

Calculation of ratio lb/ld

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

Calculation of Mu_{2+}

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

$$u = 4.7487455E-005$$

$$\mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\omega_e (5.4c) = 0.04017143$$

$$\text{ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.53375773$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{ase2} (>= \text{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{psh}_{min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 2.48363$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.48363$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$\text{psh}_2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.97078$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

$$\text{psh}_2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

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

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09471283

2 = Asl,com/(b*d)*(fs2/fc) = 0.09471283

v = Asl,mid/(b*d)*(fsv/fc) = 0.2222852

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

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

--->

$$s_u(4.8) = 0.2570428$$

$$\mu_u = M_{Rc}(4.15) = 2.5424E+009$$

$$u = s_u(4.1) = 4.7487455E-005$$

Calculation of ratio l_b/l_d

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

Calculation of μ_u

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

$$u = 4.7487455E-005$$

$$\mu_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01151713$$

$$\mu_{we}(5.4c) = 0.04017143$$

$$\mu_{ase}((5.4d), TBDY) = (\alpha_1 * A_{ext} + \alpha_2 * A_{int}) / A_{sec} = 0.53375773$$

$$\alpha_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\alpha_2 (\geq \alpha_1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{psh}_{min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 2.48363$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.48363$$

$$\text{psh}_1((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1}(\text{Length of stirrups along } Y) = 2160.00$$

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

$$\text{psh}_2(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2}(\text{Length of stirrups along } Y) = 1568.00$$

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

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$
 Lstir1 (Length of stirrups along X) = 2560.00
 Astir1 (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 Lstir2 (Length of stirrups along X) = 1968.00
 Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07936942

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07936942$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09471283$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09471283$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$$s_u (4.8) = 0.2570428$$

$$M_u = M_{Rc} (4.15) = 2.5424E+009$$

$$u = s_u (4.1) = 4.7487455E-005$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.6067E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.6067E+006$

$$V_{r1} = V_{CoI} ((10.3), ASCE 41-17) = k_{nl} * V_{CoI0}$$

$$V_{CoI0} = 1.6067E+006$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$M_u = 1.22925$$

$$V_u = 1.5362867E-036$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.022$$

$$A_g = 427500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{sjacket} + V_{s,core} = 1.1114E+006$$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 977392.20$$

$V_{sj1} = 314161.779$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col,j1 = 1.00$

$$s/d = 0.27777778$$

$V_{sj2} = 663230.422$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col,j2 = 1.00$

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.25$$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 0.41666667$$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.6067E+006$

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

$$V_{Col0} = 1.6067E+006$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\mu_u = 1.22925$$

$$V_u = 1.5362867E-036$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.022$$

$$A_g = 427500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.1114E+006$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977392.20$$

$V_{s,j1} = 314161.779$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.25$$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

V_{s,c2} is multiplied by Col,c2 = 1.00
s/d = 0.41666667
V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: V_s + V_f <= 1.3051E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:

Jacket

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

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

Concrete Elasticity, E_c = 26999.444

Steel Elasticity, E_s = 200000.00

Existing Column

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

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

Concrete Elasticity, E_c = 26999.444

Steel Elasticity, E_s = 200000.00

Max Height, H_{max} = 750.00

Min Height, H_{min} = 450.00

Max Width, W_{max} = 950.00

Min Width, W_{min} = 450.00

Eccentricity, Ecc = 250.00

Jacket Thickness, t_j = 100.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (l_b/l_d >= 1)

No FRP Wrapping

Stepwise Properties

Bending Moment, M = -209697.122

Shear Force, V₂ = -7994.629

Shear Force, V₃ = 107.5573

Axial Force, F = -21698.244

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: A_{sl,t} = 0.00

-Compression: A_{sl,c} = 6691.592

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: A_{sl,ten} = 1539.38

-Compression: A_{sl,com} = 2475.575

-Middle: A_{sl,mid} = 2676.637

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: A_{sl,ten,jacket} = 1231.504

-Compression: A_{sl,com,jacket} = 1859.823

-Middle: $Asl_{mid,jacket} = 2060.885$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten,core} = 307.8761$

-Compression: $Asl_{com,core} = 615.7522$

-Middle: $Asl_{mid,core} = 615.7522$

Mean Diameter of Tension Reinforcement, $DbL = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00550681$

$u = y + p = 0.00550681$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00308338$ ((4.29), Biskinis Phd))

$My = 8.7062E+008$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1949.632

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 1.8350E+014$

factor = 0.30

$Ag = 562500.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 21698.244$

$Ec * Ig = Ec_{jacket} * Ig_{jacket} + Ec_{core} * Ig_{core} = 6.1166E+014$

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, $b = 950.00$

web width, $bw = 450.00$

flange thickness, $t = 450.00$

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

$y_{ten} = 4.9085702E-006$

with $fy = 555.56$

$d = 707.00$

$y = 0.19956411$

$A = 0.01002107$

$B = 0.00468803$

with $pt = 0.00229194$

$pc = 0.00368581$

$pv = 0.00398517$

$N = 21698.244$

$b = 950.00$

$" = 0.06082037$

$y_{comp} = 1.5661068E-005$

with $fc = 33.00$

$Ec = 26999.444$

$y = 0.19869678$

$A = 0.00988949$

$B = 0.00462988$

with $Es = 200000.00$

CONFIRMATION: $y = 0.19956411 < t/d$

Calculation of ratio lb/d

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

- Calculation of p -

From table 10-8: $p = 0.00242342$

with:

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

shear control ratio $V_{yE}/V_{CoIOE} = 1.03465$

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

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

- $t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.0035764$

jacket: $s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00301593$

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

$L_{\text{stir1}} = 2160.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00056047$

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

$L_{\text{stir2}} = 1568.00$, 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.

$N_{UD} = 21698.244$

$A_g = 562500.00$

$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 33.00$

$f_{yE} = (f_{y_{\text{ext_Long_Reinf}}} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_{y_{\text{int_Long_Reinf}}} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} =$

555.56

$f_{tE} = (f_{y_{\text{ext_Trans_Reinf}}} \cdot s_1 + f_{y_{\text{int_Trans_Reinf}}} \cdot s_2) / (s_1 + s_2) = 555.56$

$p = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.00996292$

$b = 950.00$

$d = 707.00$

$f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

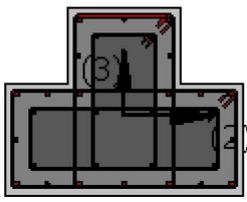
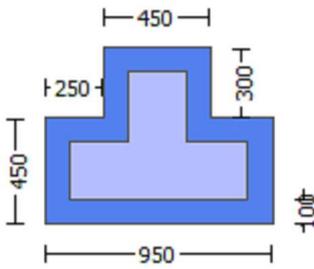
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -209697.122$
Shear Force, $V_a = 107.5573$
EDGE -B-
Bending Moment, $M_b = -112017.606$
Shear Force, $V_b = -107.5573$
BOTH EDGES
Axial Force, $F = -21698.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1539.38$
-Compression: $A_{sl,com} = 2475.575$
-Middle: $A_{sl,mid} = 2676.637$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 1.0528E+006$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 1.0528E+006$
 $V_{CoI} = 1.0528E+006$
 $k_n = 1.00$
displacement_ductility_demand = 0.00373746

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

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 3.24939$
 $M_u = 209697.122$
 $V_u = 107.5573$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 21698.244$
 $A_g = 337500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 842449.486$
where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 753982.237$
 $V_{s,j1} = 471238.898$ 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 $Col_{j1} = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 282743.339$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 88467.249$
 $V_{s,c1} = 88467.249$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 896810.169$
 $bw = 450.00$

displacement ductility demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 1.1524001E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00308338$ ((4.29), Biskinis Phd)
 $M_y = 8.7062E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1949.632
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.8350E+014$
 $factor = 0.30$
 $A_g = 562500.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 21698.244$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 6.1166E+014$

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, $b = 950.00$
web width, $bw = 450.00$
flange thickness, $t = 450.00$

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.9085702E-006$
with $f_y = 555.56$
 $d = 707.00$
 $y = 0.19956411$
 $A = 0.01002107$
 $B = 0.00468803$
with $pt = 0.00229194$
 $pc = 0.00368581$
 $pv = 0.00398517$
 $N = 21698.244$
 $b = 950.00$
 $" = 0.06082037$
 $y_{comp} = 1.5661068E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19869678$
 $A = 0.00988949$
 $B = 0.00462988$
with $E_s = 200000.00$
CONFIRMATION: $y = 0.19956411 < t/d$

Calculation of ratio l_b/d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

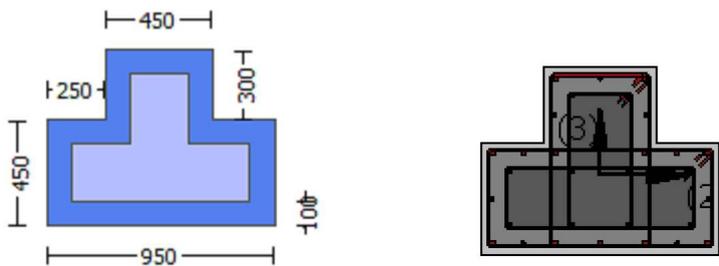
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

Max Height, $H_{max} = 750.00$

Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.22443
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u,min} > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -2.5090294E-020
EDGE -B-
Shear Force, Vb = 2.5090294E-020
BOTH EDGES
Axial Force, F = -20792.022
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , $V_e/V_r = 1.03465$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 2.0610E+009$
 $\mu_{u1+} = 1.9075E+009$, 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
 $\mu_{u1-} = 2.0610E+009$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 2.0610E+009$
 $\mu_{u2+} = 1.9075E+009$, 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
 $\mu_{u2-} = 2.0610E+009$, 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:
 $\phi_u = 5.2259729E-005$
 $M_u = 1.9075E+009$

with full section properties:

b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.022

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$$su1 = 0.4 * e_{su1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

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

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

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

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

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

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

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

$Shear_factor = 1.00$

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

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

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

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

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

with $fs2 = (fs_jacket \cdot Asl,com,jacket + fs_core \cdot Asl,com,core) / Asl,com = 694.45$

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

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.34$

$fyv = 694.45$

$suv = 0.032$

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

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

$Shear_factor = 1.00$

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

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

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

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

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

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

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

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

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.04823141$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.07756398$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.0838636$

and confined core properties:

$b = 890.00$

$d = 677.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

$c =$ confinement factor = 1.22443

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.05376434$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.08646184$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.09348412$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$v < vs,c$ - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.13390923

$Mu = MRc$ (4.15) = 1.9075E+009

$u = su$ (4.1) = 5.2259729E-005

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 6.5076774E-005$$

$$Mu = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

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

From ((5.A5), TBDY), TBDY: cc = 0.00424426
c = confinement factor = 1.22443

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

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619

2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187

v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537

and confined core properties:

b = 390.00
d = 677.00
d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.19731035

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.12269298$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21333555$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

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

---->

$$s_u(4.8) = 0.30448812$$

$$\mu_u = M_{Rc}(4.15) = 2.0610E+009$$

$$u = s_u(4.1) = 6.5076774E-005$$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2+}

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

$$u = 5.2259729E-005$$

$$\mu_u = 1.9075E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01151713$$

$$w_e(5.4c) = 0.04017143$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.48363
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426
c = confinement factor = 1.22443

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

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

lo/lou,min = lb/d = 1.00

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

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

considering characteristic value $f_{sv} = f_{sv}/1.2$, 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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04823141$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07756398$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.0838636$

and confined core properties:

$b = 890.00$

$d = 677.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05376434$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08646184$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09348412$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

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

---->

su (4.8) = 0.13390923

$Mu = MRc$ (4.15) = 1.9075E+009

$u = su$ (4.1) = 5.2259729E-005

Calculation of ratio l_b/l_d

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

Calculation of Mu_2

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

$u = 6.5076774E-005$

$Mu = 2.0610E+009$

with full section properties:

$b = 450.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00198039$

$N = 20792.022$

$f_c = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01151713$

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

From (5.4b), TBDY: $cu = 0.01151713$

we (5.4c) = 0.04017143

ase ((5.4d), TBDY) = $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.53375773$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (>=ase1) = \text{Max}(((A_{conf,max2}-A_{noConf2})/A_{conf,max2})*(A_{conf,min2}/A_{conf,max2}),0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.48363$

 $psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.48363$
 $psh1$ ((5.4d), TBDY) = $L_{stir1}*A_{stir1}/(A_{sec}*s1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ (5.4d) = $L_{stir2}*A_{stir2}/(A_{sec}*s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

 $psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.97078$
 $psh1$ ((5.4d), TBDY) = $L_{stir1}*A_{stir1}/(A_{sec}*s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ ((5.4d), TBDY) = $L_{stir2}*A_{stir2}/(A_{sec}*s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00424426$
 $c = \text{confinement factor} = 1.22443$

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

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

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

$su1 = 0.4*esu1_{nominal}$ ((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 $f_{sy1} = f_{s1}/1.2$, 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 $f_{s1} = (f_{s,jacket}*A_{s,t,en,jacket} + f_{s,core}*A_{s,t,en,core})/A_{s,t,en} = 694.45$

with $E_{s1} = (E_{s,jacket}*A_{s,t,en,jacket} + E_{s,core}*A_{s,t,en,core})/A_{s,t,en} = 200000.00$

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

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

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

$su2 = 0.4*esu2_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $es_{u2_nominal} = 0.08$,

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

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

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

with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$fy_v = 694.45$

$suv = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$suv = 0.4 \cdot es_{u2_nominal} ((5.5), TBDY) = 0.032$

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

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

$1 = Asl_{ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.16374619$

$2 = Asl_{com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.10182187$

$v = Asl_{mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.17704537$

and confined core properties:

$b = 390.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.40604$

$cc (5A.5, TBDY) = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$1 = Asl_{ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.19731035$

$2 = Asl_{com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.12269298$

$v = Asl_{mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.21333555$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$su (4.8) = 0.30448812$

$Mu = MRc (4.15) = 2.0610E+009$

$u = su (4.1) = 6.5076774E-005$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.3280E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.3280E+006$

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

$V_{Col0} = 1.3280E+006$

$knl = 1$ (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: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1534.018$$

$$V_u = 2.5090294E-020$$

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

$$N_u = 20792.022$$

$$A_g = 337500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 936062.473$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$$

$V_{s,j1} = 523602.964$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

$V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 0.56818182$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.25$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.0304E+006$$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280E+006$

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

$$V_{Col0} = 1.3280E+006$$

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

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

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

$$\text{Mean concrete strength: } f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00, \text{ but } f_c'^{0.5} \leq 8.3$$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1534.018$$

$$V_u = 2.5090294E-020$$

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

$$N_u = 20792.022$$

$$A_g = 337500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 936062.473$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$$

$V_{s,j1} = 523602.964$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$f_y = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$
 $V_{s,c1} = 98297.73$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f <= 1.0304E+006$
 $bw = 450.00$

 End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcjtcs

Constant Properties

 Knowledge Factor, $= 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $Ecc = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.22443
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.5362867E-036$
EDGE -B-
Shear Force, $V_b = -1.5362867E-036$
BOTH EDGES
Axial Force, $F = -20792.022$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1539.38$
-Compression: $A_{sc,com} = 1539.38$
-Middle: $A_{st,mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.0549$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6949E+006$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 2.5424E+009$
 $\mu_{u1+} = 2.5424E+009$, 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
 $\mu_{u1-} = 2.5424E+009$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 2.5424E+009$
 $\mu_{u2+} = 2.5424E+009$, 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
 $\mu_{u2-} = 2.5424E+009$, 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:
 $\phi_u = 4.7487455E-005$
 $M_u = 2.5424E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.022$
 $f_c = 33.00$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

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

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

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

$$lo/lo_{ou,min} = lb/lb_{,min} = 1.00$$

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.07936942$$

$$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.07936942$$

$$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 40.40604$$

$$cc \text{ (5A.5, TBDY)} = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.09471283$$

$$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.09471283$$

$$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$v < vs,c$ - RHS eq.(4.5) is satisfied

--->

$$su \text{ (4.8)} = 0.2570428$$

$$Mu = MRc \text{ (4.15)} = 2.5424E+009$$

$$u = su \text{ (4.1)} = 4.7487455E-005$$

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 4.7487455E-005$$

$$\mu_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } \omega: \omega^* = \text{shear_factor} * \text{Max}(\omega, \omega_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } \omega_c = 0.01151713$$

$$\omega_{ve} (5.4c) = 0.04017143$$

$$\omega_{ase} ((5.4d), TBDY) = (\omega_{se1} * A_{ext} + \omega_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\omega_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\omega_{se2} (> \omega_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{yve} = \text{Min}(p_{sh,x} * F_{yve}, p_{sh,y} * F_{yve}) = 2.48363$$

$$p_{sh,x} * F_{yve} = p_{sh1} * F_{yve1} + p_{sh2} * F_{yve2} = 2.48363$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$p_{sh,y} * F_{yve} = p_{sh1} * F_{yve1} + p_{sh2} * F_{yve2} = 2.97078$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$s_2 = 250.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 1.00$
 $su_1 = 0.4 * esu_1 \text{ nominal} ((5.5), TBDY) = 0.032$
 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 $fs_1 = (fs_{jacket} * A_{sl, ten, jacket} + fs_{core} * A_{sl, ten, core}) / A_{sl, ten} = 694.45$
 with $Es_1 = (Es_{jacket} * A_{sl, ten, jacket} + Es_{core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2 \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl, com, jacket} + fs_{core} * A_{sl, com, core}) / A_{sl, com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl, com, jacket} + Es_{core} * A_{sl, com, core}) / A_{sl, com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 1.00$
 $suv = 0.4 * esuv \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_v, sh_v, ft_v, fy_v , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * A_{sl, mid, jacket} + fs_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl, mid, jacket} + Es_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 200000.00$
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.07936942$
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.07936942$
 $v = A_{sl, mid} / (b * d) * (fsv / f_c) = 0.18627516$
 and confined core properties:
 $b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.09471283$
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.09471283$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.2222852$$

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

--->

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

--->

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

--->

$$s_u(4.8) = 0.2570428$$

$$M_u = M_{Rc}(4.15) = 2.5424E+009$$

$$u = s_u(4.1) = 4.7487455E-005$$

Calculation of ratio l_b/d

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

Calculation of M_{u2+}

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

$$u = 4.7487455E-005$$

$$M_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01151713$$

$$\phi_{we}(5.4c) = 0.04017143$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh_x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 = $(f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$

with Es1 = $(E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

with fs2 = $(f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 694.45$

with Es2 = $(E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

For calculation of $e_{sv_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

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

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

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

$$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07936942$$

$$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07936942$$

$$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$f_{cc} \text{ (5A.2, TBDY)} = 40.40604$$

$$c_c \text{ (5A.5, TBDY)} = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09471283$$

$$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09471283$$

$$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$$s_u \text{ (4.8)} = 0.2570428$$

$$M_u = M_{Rc} \text{ (4.15)} = 2.5424E+009$$

$$u = s_u \text{ (4.1)} = 4.7487455E-005$$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2}

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

$$u = 4.7487455E-005$$

$$M_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase_2 (>= ase_1) = \text{Max}(((A_{conf,max2} - \text{AnoConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{,min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

 $psh_x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.48363$
 psh_1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
 psh_2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

 $psh_y * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.97078$
 psh_1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
 psh_2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

su2 = $0.4 * esu2_{nominal}$ ((5.5), TBDY) = 0.032

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

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

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

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

with $Es_2 = (Es_{jacket} \cdot Asl_{,com,jacket} + Es_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$fy_v = 694.45$

$suv = 0.032$

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

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

$suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

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

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

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

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07936942$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07936942$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.18627516$

and confined core properties:

$b = 390.00$

$d = 877.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.40604$

$cc (5A.5, TBDY) = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09471283$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09471283$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.2222852$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$su (4.8) = 0.2570428$

$Mu = MRc (4.15) = 2.5424E+009$

$u = su (4.1) = 4.7487455E-005$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.6067E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.6067E+006$

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

$V_{Co10} = 1.6067E+006$

$knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$
 $\mu = 1.22925$
 $V_u = 1.5362867E-036$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 20792.022$
 $A_g = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.1114E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977392.20$
 $V_{sj1} = 314161.779$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 663230.422$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 134042.359$ is calculated for section flange core, with:
 $d = 600.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.6067E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 1.6067E+006$
 $knl = 1$ (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).

$f = 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu = 1.22925$
 $V_u = 1.5362867E-036$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 20792.022$
 $A_g = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.1114E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977392.20$
 $V_{sj1} = 314161.779$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.56$

s = 100.00
Vs,j1 is multiplied by Col,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 663230.422 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by Col,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 134042.359
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by Col,c1 = 0.00
s/d = 1.25
Vs,c2 = 134042.359 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c2 is multiplied by Col,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 1.3051E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars

Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -2.4201E+007$
Shear Force, $V2 = -7994.629$
Shear Force, $V3 = 107.5573$
Axial Force, $F = -21698.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1539.38$
-Compression: $As_{c,com} = 1539.38$
-Middle: $As_{c,mid} = 3612.832$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 1231.504$
-Compression: $As_{c,com,jacket} = 1231.504$
-Middle: $As_{c,mid,jacket} = 2689.203$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 307.8761$
-Compression: $As_{c,com,core} = 307.8761$
-Middle: $As_{c,mid,core} = 923.6282$
Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00675446$
 $u = y + p = 0.00675446$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00433459$ ((4.29), Biskinis Phd))
 $M_y = 1.1980E+009$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3027.121
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.7887E+014$
factor = 0.30
 $A_g = 562500.00$
Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 21698.244$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 9.2958E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.1203973E-006$
with $f_y = 555.56$
 $d = 907.00$
 $y = 0.25671634$
 $A = 0.01649063$
 $B = 0.00868179$
with $pt = 0.0037716$
 $pc = 0.0037716$
 $pv = 0.00885172$
 $N = 21698.244$
 $b = 450.00$

" = 0.04740904
y_comp = 9.4777787E-006
with fc = 33.00
Ec = 26999.444
y = 0.25592798
A = 0.01627411
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.00241987

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1

shear control ratio $V_y E / V_{Co} I_{OE} = 1.0549$

d = d_external = 907.00

s = s_external = 0.00

- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00427788$

jacket: $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00357443$

Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction

Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction

s1 = 100.00

core: $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00070345$

Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction

Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction

s2 = 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.

NUD = 21698.244

Ag = 562500.00

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

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

$f_{yIE} = (f_{y_ext_Trans_Reinf} * s_1 + f_{y_int_Trans_Reinf} * s_2) / (s_1 + s_2) = 555.56$

$p_l = Area_Tot_Long_Rein / (b * d) = 0.01639493$

b = 450.00

d = 907.00

f_{cE} = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

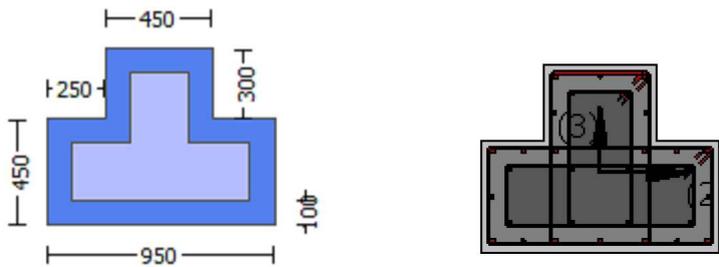
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -2.4201E+007$
Shear Force, $V_a = -7994.629$
EDGE -B-
Bending Moment, $M_b = 212176.02$
Shear Force, $V_b = 7994.629$
BOTH EDGES
Axial Force, $F = -21698.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1539.38$
-Compression: $A_{st,com} = 1539.38$
-Middle: $A_{st,mid} = 3612.832$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 1.4321E+006$
 V_n ((10.3), ASCE 41-17) = $knI \cdot V_{CoI0} = 1.4321E+006$
 $V_{CoI} = 1.4321E+006$
 $knI = 1.00$
 $displacement_ductility_demand = 0.03080719$

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

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 212176.02$
 $V_u = 7994.629$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 21698.244$
 $A_g = 427500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0003E+006$
where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 879645.943$
 $V_{sj1} = 282743.339$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 596902.604$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 120637.158$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 250.00$$

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

$$s/d = 1.25$$

$V_{s,c2} = 120637.158$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 250.00$$

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

$$s/d = 0.41666667$$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1360E+006$

$$bw = 450.00$$

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 $\theta = 1.3234006E-005$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00042958 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.1980E+009$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 300.00$$

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 2.7887E+014$

$$\text{factor} = 0.30$$

$$A_g = 562500.00$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$$

$$N = 21698.244$$

$$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 9.2958E+014$$

Calculation of Yielding Moment M_y

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

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

$$y_{ten} = 4.1203973E-006$$

with $f_y = 555.56$

$$d = 907.00$$

$$y = 0.25671634$$

$$A = 0.01649063$$

$$B = 0.00868179$$

with $p_t = 0.0037716$

$$p_c = 0.0037716$$

$$p_v = 0.00885172$$

$$N = 21698.244$$

$$b = 450.00$$

$$r = 0.04740904$$

$$y_{comp} = 9.4777787E-006$$

with $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.25592798$$

$$A = 0.01627411$$

$$B = 0.0085861$$

with $E_s = 200000.00$

Calculation of ratio I_b / I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

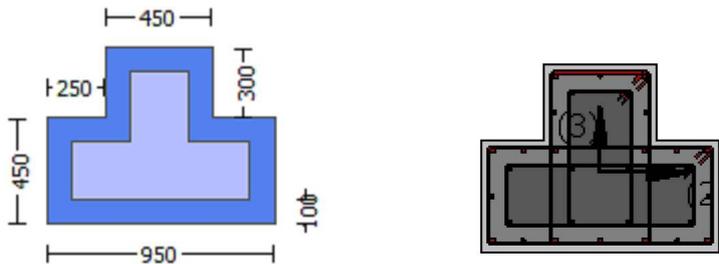
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

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

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{o,min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -2.5090294E-020$

EDGE -B-

Shear Force, $V_b = 2.5090294E-020$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1539.38$

-Compression: $A_{st,com} = 2475.575$

-Middle: $A_{st,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.03465$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.0610E+009$

$Mu_{1+} = 1.9075E+009$, 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

$Mu_{1-} = 2.0610E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.0610E+009$

$Mu_{2+} = 1.9075E+009$, 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

$Mu_{2-} = 2.0610E+009$, 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:

$\phi_u = 5.2259729E-005$

$Mu = 1.9075E+009$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$f_{y1} = 694.45$
 $s_{u1} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{u1} = 0.4 * e_{s_{u1,nominal}} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{s_{u1,nominal}} = 0.08$,
 For calculation of $e_{s_{u1,nominal}}$ and y_1, sh_1, ft_1, f_{y1} , it is considered
 characteristic value $f_{s_{y1}} = f_{s1}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s1} = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$
 with $E_{s1} = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $f_{y2} = 694.45$
 $s_{u2} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $s_{u2} = 0.4 * e_{s_{u2,nominal}} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{s_{u2,nominal}} = 0.08$,
 For calculation of $e_{s_{u2,nominal}}$ and y_2, sh_2, ft_2, f_{y2} , it is considered
 characteristic value $f_{s_{y2}} = f_{s2}/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, f_{y2} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s2} = (f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 694.45$
 with $E_{s2} = (E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $f_{y_v} = 694.45$
 $s_{u_v} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{u_v} = 0.4 * e_{s_{u_v,nominal}} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{s_{u_v,nominal}} = 0.08$,
 considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY
 For calculation of $e_{s_{u_v,nominal}}$ and y_v, sh_v, ft_v, f_{y_v} , it is considered
 characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s_v} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$
 with $E_{s_v} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.04823141$
 $2 = A_{s2,com} / (b * d) * (f_{s2} / f_c) = 0.07756398$
 $v = A_{s,mid} / (b * d) * (f_{s_v} / f_c) = 0.0838636$
 and confined core properties:
 $b = 890.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.05376434$
 $2 = A_{s2,com} / (b * d) * (f_{s2} / f_c) = 0.08646184$
 $v = A_{s,mid} / (b * d) * (f_{s_v} / f_c) = 0.09348412$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $s_u (4.8) = 0.13390923$

$$\begin{aligned} \text{Mu} &= \text{MRc (4.15)} = 1.9075\text{E}+009 \\ u &= \text{su (4.1)} = 5.2259729\text{E}-005 \end{aligned}$$

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

$$\begin{aligned} u &= 6.5076774\text{E}-005 \\ \text{Mu} &= 2.0610\text{E}+009 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 450.00 \\ d &= 707.00 \\ d' &= 43.00 \\ v &= 0.00198039 \\ N &= 20792.022 \\ f_c &= 33.00 \end{aligned}$$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$

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

From (5.4b), TBDY: $\phi_u = 0.01151713$

we (5.4c) = 0.04017143

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773

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 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.48363

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.48363

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.97078

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443

Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619

2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187

v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537

and confined core properties:

$b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19731035$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12269298$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21333555$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.30448812$
 $Mu = MRc (4.15) = 2.0610E+009$
 $u = su (4.1) = 6.5076774E-005$

 Calculation of ratio l_b/d

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

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 5.2259729E-005$
 $Mu = 1.9075E+009$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.022$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01151713$
 $we (5.4c) = 0.04017143$
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.53375773$
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 2.48363$

 $psh_{,x} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.48363$
 $psh_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $psh_2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

 $psh_{,y} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.97078$
 $psh_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh_2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

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

$lo/lou_{,min} = lb/l_d = 1.00$

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

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

with $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

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

$lo/lou_{,min} = lb/l_{b,min} = 1.00$

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

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

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

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

with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$fy_v = 694.45$

suv = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141

2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398

v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636

and confined core properties:

b = 890.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434

2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184

v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.8) = 0.13390923

Mu = MRc (4.15) = 1.9075E+009

u = su (4.1) = 5.2259729E-005

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

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

u = 6.5076774E-005

Mu = 2.0610E+009

with full section properties:

b = 450.00

d = 707.00

d' = 43.00

v = 0.00198039

N = 20792.022

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01151713

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

From (5.4b), TBDY: cu = 0.01151713

we (5.4c) = 0.04017143

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.48363$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.97078$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

$Shear_factor = 1.00$

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

$su1 = 0.4 * esu1_nominal$ ((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 $fs1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$

with $Es1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537$$

and confined core properties:

$$b = 390.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.19731035$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12269298$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.21333555$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$v < vs,c$ - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.30448812$$

$$Mu = MRc (4.15) = 2.0610E+009$$

$$u = su (4.1) = 6.5076774E-005$$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1,Vr2) = 1.3280E+006$

Calculation of Shear Strength at edge 1, $Vr1 = 1.3280E+006$

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO$$

$$VColO = 1.3280E+006$$

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

$M/Vd = 2.00$

$\mu_u = 1534.018$

$V_u = 2.5090294E-020$

$d = 0.8 \cdot h = 600.00$

$N_u = 20792.022$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 936062.473$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$

$V_{s,j1} = 523602.964$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.56818182$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$

$b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280E+006$

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

$V_{Col0} = 1.3280E+006$

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

$M/Vd = 2.00$

$\mu_u = 1534.018$

$V_u = 2.5090294E-020$

$d = 0.8 \cdot h = 600.00$

$N_u = 20792.022$

$A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 936062.473$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$
 $V_{s,j1} = 523602.964$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$
 $V_{s,c1} = 98297.73$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$
 $bw = 450.00$

 End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcjtcs

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

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

Existing Column

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

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.5362867E-036$

EDGE -B-

Shear Force, $V_b = -1.5362867E-036$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1539.38$

-Compression: $As_{c,com} = 1539.38$

-Middle: $As_{mid} = 3612.832$

Calculation of Shear Capacity ratio , $V_e/V_r = 1.0549$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6949E+006$
with

$M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 2.5424E+009$

$Mu_{1+} = 2.5424E+009$, 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

$Mu_{1-} = 2.5424E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 2.5424E+009$

$Mu_{2+} = 2.5424E+009$, 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

$Mu_{2-} = 2.5424E+009$, 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:

$\phi_u = 4.7487455E-005$

$Mu = 2.5424E+009$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09471283

2 = Asl,com/(b*d)*(fs2/fc) = 0.09471283

v = Asl,mid/(b*d)*(fsv/fc) = 0.2222852

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.2570428

Mu = MRc (4.15) = 2.5424E+009

$$u = s_u(4.1) = 4.7487455E-005$$

Calculation of ratio l_b/d

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

Calculation of μ_1

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

$$u = 4.7487455E-005$$

$$\mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e(5.4c) = 0.04017143$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

$d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09471283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09471283$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.2222852$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

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

--->
 $s_u (4.8) = 0.2570428$
 $M_u = M_{Rc} (4.15) = 2.5424E+009$
 $u = s_u (4.1) = 4.7487455E-005$

Calculation of ratio l_b/d

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

Calculation of M_{u2+}

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

$u = 4.7487455E-005$
 $M_u = 2.5424E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.022$

$f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$

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

From (5.4b), TBDY: $cu = 0.01151713$

$w_e (5.4c) = 0.04017143$

$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$

$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $bi^2/6$ as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.48363

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.48363
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

$l_0/l_{0u,min} = l_b/l_d = 1.00$

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

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

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

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

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

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

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

$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.07936942$

$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.07936942$

$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.18627516$

and confined core properties:

$b = 390.00$

$d = 877.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.40604$

$cc (5A.5, TBDY) = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.09471283$

$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.09471283$

$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.2222852$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$s_u (4.8) = 0.2570428$

$M_u = M_{Rc} (4.15) = 2.5424E+009$

$u = s_u (4.1) = 4.7487455E-005$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2} -

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

$u = 4.7487455E-005$

$M_u = 2.5424E+009$

with full section properties:

$b = 450.00$

$d = 907.00$

$d' = 43.00$

$v = 0.0015437$

$N = 20792.022$

$f_c = 33.00$

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

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, cc) = 0.01151713$

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

From (5.4b), TBDY: $c_u = 0.01151713$

$w_e (5.4c) = 0.04017143$

$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$

c = confinement factor = 1.22443

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

$su1 = 0.4 * esu1_{nominal}$ ((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 $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 694.45$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$$su_2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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.

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

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

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.07936942$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.07936942$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.09471283$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.09471283$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

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

---->

$$su (4.8) = 0.2570428$$

$$Mu = MRc (4.15) = 2.5424E+009$$

$$u = su (4.1) = 4.7487455E-005$$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.6067E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.6067E+006$

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

$$V_{Col0} = 1.6067E+006$$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.22925$

$V_u = 1.5362867E-036$

$d = 0.8 \cdot h = 760.00$

$N_u = 20792.022$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 1.1114E+006$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 977392.20$

$V_{s,j1} = 314161.779$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.13157895$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 134042.359$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$

$b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.6067E+006$

$V_{r2} = V_{\text{Col}}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 1.6067E+006$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.22925$

$V_u = 1.5362867E-036$

$d = 0.8 \cdot h = 760.00$

$N_u = 20792.022$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.1114E+006$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977392.20$

$V_{s,j1} = 314161.779$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$

$bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$
Eccentricity, $Ecc = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d >= 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -112017.606$
Shear Force, $V_2 = 7994.629$
Shear Force, $V_3 = -107.5573$
Axial Force, $F = -21698.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 1539.38$
-Compression: $A_{s,com} = 2475.575$
-Middle: $A_{s,mid} = 2676.637$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten,jacket} = 1231.504$
-Compression: $A_{s,com,jacket} = 1859.823$
-Middle: $A_{s,mid,jacket} = 2060.885$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten,core} = 307.8761$
-Compression: $A_{s,com,core} = 615.7522$
-Middle: $A_{s,mid,core} = 615.7522$
Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.00407053$
 $u = \gamma + \rho = 0.00407053$

- Calculation of γ -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.0016471$ ((4.29), Biskinis Phd))
 $M_y = 8.7062E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1041.469
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.8350E+014$
 $factor = 0.30$
 $A_g = 562500.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 21698.244$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 6.1166E+014$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

Assuming neutral axis within flange ($\gamma < t/d$, compression zone rectangular) with:
flange width, $b = 950.00$
web width, $b_w = 450.00$
flange thickness, $t = 450.00$

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 4.9085702\text{E}-006$
 with $f_y = 555.56$
 $d = 707.00$
 $y = 0.19956411$
 $A = 0.01002107$
 $B = 0.00468803$
 with $pt = 0.00229194$
 $pc = 0.00368581$
 $pv = 0.00398517$
 $N = 21698.244$
 $b = 950.00$
 $" = 0.06082037$
 $y_{\text{comp}} = 1.5661068\text{E}-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19869678$
 $A = 0.00988949$
 $B = 0.00462988$
 with $E_s = 200000.00$
 CONFIRMATION: $y = 0.19956411 < t/d$

 Calculation of ratio l_b/d

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

 - Calculation of p -

From table 10-8: $p = 0.00242342$

with:

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

shear control ratio $V_y E / V_{CoI} E = 1.03465$

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

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

- $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.0035764$

jacket: $s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00301593$

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

$L_{\text{stir1}} = 2160.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00056047$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1568.00$, 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.

$N_{UD} = 21698.244$

$A_g = 562500.00$

$f_{cE} = (f_{c_jacket} \cdot \text{Area}_{\text{jacket}} + f_{c_core} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 33.00$

$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_{y_int_Long_Reinf} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} =$

555.56

$f_{yIE} = (f_{y_ext_Trans_Reinf} \cdot s_1 + f_{y_int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$

$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.00996292$

$b = 950.00$

$d = 707.00$

$f_{cE} = 33.00$

 End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 7

column C1, Floor 1

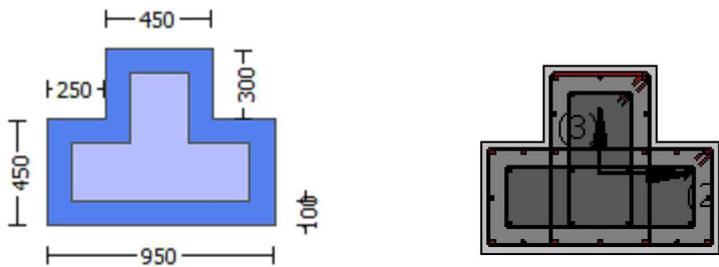
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 450.00$
 Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $Ecc = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 No FRP Wrapping

 Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -209697.122$
 Shear Force, $V_a = 107.5573$
 EDGE -B-
 Bending Moment, $M_b = -112017.606$
 Shear Force, $V_b = -107.5573$
 BOTH EDGES
 Axial Force, $F = -21698.244$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1539.38$
 -Compression: $As_{c,com} = 2475.575$
 -Middle: $As_{mid} = 2676.637$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 1.1843E+006$
 V_n (10.3, ASCE 41-17) = $k_n \cdot V_{CoIO} = 1.1843E+006$
 $V_{CoI} = 1.1843E+006$
 $k_n = 1.00$
 displacement_ductility_demand = $2.1145761E-007$

 NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

 = 1 (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 112017.606$
 $V_u = 107.5573$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 21698.244$
 $Ag = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 842449.486$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 753982.237$
 $V_{sj1} = 471238.898$ 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 $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 282743.339$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 88467.249$
 $V_{s,c1} = 88467.249$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 896810.169$
 $bw = 450.00$

displacement ductility demand is calculated as ϕ / y

- Calculation of ϕ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 3.4829268E-010$
 $y = (M_y * L_s / 3) / E_{eff} = 0.0016471$ ((4.29), Biskinis Phd))
 $M_y = 8.7062E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1041.469
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.8350E+014$
 $factor = 0.30$
 $A_g = 562500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 21698.244$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 6.1166E+014$

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, $b = 950.00$
 web width, $bw = 450.00$
 flange thickness, $t = 450.00$

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.9085702E-006$
 with $f_y = 555.56$
 $d = 707.00$
 $y = 0.19956411$
 $A = 0.01002107$
 $B = 0.00468803$
 with $pt = 0.00229194$
 $pc = 0.00368581$

pv = 0.00398517
N = 21698.244
b = 950.00
" = 0.06082037
y_comp = 1.5661068E-005
with fc = 33.00
Ec = 26999.444
y = 0.19869678
A = 0.00988949
B = 0.00462988
with Es = 200000.00
CONFIRMATION: $y = 0.19956411 < t/d$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

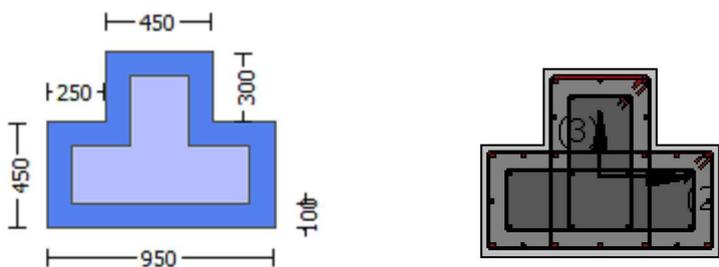
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjctcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
Existing Column
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $E_{cc} = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.22443
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou, min} > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -2.5090294E-020$
EDGE -B-
Shear Force, $V_b = 2.5090294E-020$
BOTH EDGES
Axial Force, $F = -20792.022$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl, ten} = 1539.38$
-Compression: $A_{sl, com} = 2475.575$
-Middle: $A_{sl, mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.03465$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.0610E+009$
 $M_{u1+} = 1.9075E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination

Mu1- = 2.0610E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

Mpr2 = Max(Mu2+ , Mu2-) = 2.0610E+009

Mu2+ = 1.9075E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

Mu2- = 2.0610E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu1+

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 5.2259729E-005$

Mu = 1.9075E+009

with full section properties:

b = 950.00

d = 707.00

d' = 43.00

v = 0.00093808

N = 20792.022

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_{cu} = 0.01151713$

we (5.4c) = 0.04017143

ase ((5.4d), TBDY) = $(\text{ase1} * \text{Aext} + \text{ase2} * \text{Aint}) / \text{Asec} = 0.53375773$

ase1 = $\text{Max}(((\text{Aconf,max1} - \text{AnoConf1}) / \text{Aconf,max1}) * (\text{Aconf,min1} / \text{Aconf,max1}), 0) = 0.53375773$

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 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

ase2 (\geq ase1) = $\text{Max}(((\text{Aconf,max2} - \text{AnoConf2}) / \text{Aconf,max2}) * (\text{Aconf,min2} / \text{Aconf,max2}), 0) = 0.53375773$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

psh,min*Fywe = $\text{Min}(\text{psh,x}*Fywe, \text{psh,y}*Fywe) = 2.48363$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.48363

psh1 ((5.4d), TBDY) = $\text{Lstir1} * \text{Astir1} / (\text{Asec} * s1) = 0.00301593$

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = $\text{Lstir2} * \text{Astir2} / (\text{Asec} * s2) = 0.00056047$

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.97078

psh1 ((5.4d), TBDY) = $\text{Lstir1} * \text{Astir1} / (\text{Asec} * s1) = 0.00357443$

Lstir1 (Length of stirrups along X) = 2560.00

Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141

2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398

v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636

and confined core properties:

b = 890.00

$d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05376434$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08646184$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09348412$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->

$su (4.8) = 0.13390923$
 $Mu = MRc (4.15) = 1.9075E+009$
 $u = su (4.1) = 5.2259729E-005$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 6.5076774E-005$
 $Mu = 2.0610E+009$

with full section properties:

$b = 450.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00198039$
 $N = 20792.022$

$f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.01151713$

$we (5.4c) = 0.04017143$

$ase ((5.4d), TBDY) = (ase1*A_{ext}+ase2*A_{int})/A_{sec} = 0.53375773$

$ase1 = \text{Max}(((A_{conf,max1}-A_{noConf1})/A_{conf,max1})*(A_{conf,min1}/A_{conf,max1}),0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (\geq ase1) = \text{Max}(((A_{conf,max2}-A_{noConf2})/A_{conf,max2})*(A_{conf,min2}/A_{conf,max2}),0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $bi^2/6$ as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.48363

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.48363
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_0/l_{0,min} = l_b/l_d = 1.00$

$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and γ_v , sh_v, ft_v, fy_v , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

$\gamma_1, sh_1, ft_1, fy_1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$

with $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.16374619$

$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.10182187$

$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.17704537$

and confined core properties:

$b = 390.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.40604$

$cc (5A.5, TBDY) = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.19731035$

$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.12269298$

$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.21333555$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$s_u (4.8) = 0.30448812$

$M_u = M_{Rc} (4.15) = 2.0610E+009$

$u = s_u (4.1) = 6.5076774E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of M_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 5.2259729E-005$

$M_u = 1.9075E+009$

with full section properties:

$b = 950.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093808$

$N = 20792.022$

$f_c = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, cc) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01151713$

$w_e (5.4c) = 0.04017143$

$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$

$psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$

c = confinement factor = 1.22443

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$ ((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 $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 694.45$

with $Es1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$$

$$\text{with } Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY.

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.

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$$

$$\text{with } Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.04823141$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.07756398$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.0838636$$

and confined core properties:

$$b = 890.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.05376434$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.08646184$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.09348412$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs_{y2}$ - LHS eq.(4.5) is not satisfied

---->

$v < vs_c$ - RHS eq.(4.5) is satisfied

---->

$$su (4.8) = 0.13390923$$

$$Mu = MRc (4.15) = 1.9075E+009$$

$$u = su (4.1) = 5.2259729E-005$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.5076774E-005$$

$$Mu = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$f_{y1} = 694.45$
 $s_{u1} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{u1} = 0.4 * e_{s1_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{s1_nominal} = 0.08$,
 For calculation of $e_{s1_nominal}$ and y_1, sh_1, ft_1, f_{y1} , it is considered
 characteristic value $f_{s1} = f_{s1}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s1} = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$
 with $E_{s1} = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $f_{y2} = 694.45$
 $s_{u2} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $s_{u2} = 0.4 * e_{s2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{s2_nominal} = 0.08$,
 For calculation of $e_{s2_nominal}$ and y_2, sh_2, ft_2, f_{y2} , it is considered
 characteristic value $f_{s2} = f_{s2}/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, f_{y2} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s2} = (f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 694.45$
 with $E_{s2} = (E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $f_{y_v} = 694.45$
 $s_{u_v} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{u_v} = 0.4 * e_{s_{u_v}}_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{s_{u_v}}_nominal = 0.08$,
 considering characteristic value $f_{s_{u_v}} = f_{s_{u_v}}/1.2$, from table 5.1, TBDY
 For calculation of $e_{s_{u_v}}_nominal$ and y_v, sh_v, ft_v, f_{y_v} , it is considered
 characteristic value $f_{s_{u_v}} = f_{s_{u_v}}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s_{u_v}} = (f_{s,jacket} * A_{s_{u_v},mid,jacket} + f_{s,mid} * A_{s_{u_v},mid,core}) / A_{s_{u_v},mid} = 694.45$
 with $E_{s_{u_v}} = (E_{s,jacket} * A_{s_{u_v},mid,jacket} + E_{s,mid} * A_{s_{u_v},mid,core}) / A_{s_{u_v},mid} = 200000.00$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.16374619$
 $2 = A_{s2,com} / (b * d) * (f_{s2} / f_c) = 0.10182187$
 $v = A_{s_{u_v},mid} / (b * d) * (f_{s_{u_v}} / f_c) = 0.17704537$
 and confined core properties:
 $b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.19731035$
 $2 = A_{s2,com} / (b * d) * (f_{s2} / f_c) = 0.12269298$
 $v = A_{s_{u_v},mid} / (b * d) * (f_{s_{u_v}} / f_c) = 0.21333555$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $s_u (4.8) = 0.30448812$

$$\begin{aligned} \mu &= MRC(4.15) = 2.0610E+009 \\ u &= su(4.1) = 6.5076774E-005 \end{aligned}$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.3280E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.3280E+006$

$V_{r1} = V_{Co1} ((10.3), ASCE 41-17) = k_{nl} * V_{Co10}$

$$V_{Co10} = 1.3280E+006$$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1534.018$$

$$V_u = 2.5090294E-020$$

$$d = 0.8 * h = 600.00$$

$$N_u = 20792.022$$

$$A_g = 337500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 936062.473$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 837764.743$$

$V_{sj1} = 523602.964$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$$s/d = 0.16666667$$

$V_{sj2} = 314161.779$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$$s/d = 0.27777778$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$

$$s/d = 1.25$$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$

$$b_w = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280E+006$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 1.3280E+006$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1534.018$

$\nu_u = 2.5090294E-020$

$d = 0.8 * h = 600.00$

$N_u = 20792.022$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 936062.473$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 837764.743$

$V_{sj1} = 523602.964$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$s/d = 0.16666667$

$V_{sj2} = 314161.779$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$s/d = 0.27777778$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$

$s/d = 1.25$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$

$bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjtcs

Constant Properties

```

Knowledge Factor,  $\phi = 1.00$ 
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
Max Height,  $H_{max} = 750.00$ 
Min Height,  $H_{min} = 450.00$ 
Max Width,  $W_{max} = 950.00$ 
Min Width,  $W_{min} = 450.00$ 
Eccentricity,  $E_{cc} = 250.00$ 
Jacket Thickness,  $t_j = 100.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.22443
Element Length,  $L = 3000.00$ 
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou, min} > 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force,  $V_a = 1.5362867E-036$ 
EDGE -B-
Shear Force,  $V_b = -1.5362867E-036$ 
BOTH EDGES
Axial Force,  $F = -20792.022$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{st} = 0.00$ 
-Compression:  $A_{sc} = 6691.592$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{sl, ten} = 1539.38$ 
-Compression:  $A_{sl, com} = 1539.38$ 
-Middle:  $A_{sl, mid} = 3612.832$ 
-----
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 1.0549$ 
Member Controlled by Shear ( $V_e/V_r > 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6949E+006$ 
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.5424E+009$ 
 $M_{u1+} = 2.5424E+009$ , 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
 $M_{u1-} = 2.5424E+009$ , 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

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.5424E+009$$

$M_{u2+} = 2.5424E+009$, 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

$M_{u2-} = 2.5424E+009$, 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:

$$\phi_u = 4.7487455E-005$$

$$M_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01151713$$

$$\phi_{we} \text{ (5.4c)} = 0.04017143$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (\geq \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

psh2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = $0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = $(f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$

with Es1 = $(E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = $0.4 * esu2_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = $(f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 694.45$

with Es2 = $(E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = $0.4 * esuv_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = $(f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$

with Esv = $(E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$

1 = $A_{s,ten} / (b * d) * (fs1 / fc) = 0.07936942$

2 = $A_{s,com} / (b * d) * (fs2 / fc) = 0.07936942$

v = $A_{s,mid} / (b * d) * (fsv / fc) = 0.18627516$

and confined core properties:

b = 390.00

d = 877.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09471283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09471283$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.2222852$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.2570428$
 $Mu = MRc (4.15) = 2.5424E+009$
 $u = su (4.1) = 4.7487455E-005$

 Calculation of ratio l_b/d

 Adequate Lap Length: $l_b/d \geq 1$

 Calculation of Mu_1 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 4.7487455E-005$
 $Mu = 2.5424E+009$

 with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.022$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01151713$
 $we (5.4c) = 0.04017143$
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.53375773$
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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.

$AnoConf2 = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$
 $c = \text{confinement factor} = 1.22443$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lou_{min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lou_{min} = lb/lb_{min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu2_{nominal} = 0.08$,

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

with $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09471283

2 = Asl,com/(b*d)*(fs2/fc) = 0.09471283

v = Asl,mid/(b*d)*(fsv/fc) = 0.2222852

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.2570428

Mu = MRc (4.15) = 2.5424E+009

u = su (4.1) = 4.7487455E-005

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 4.7487455E-005

Mu = 2.5424E+009

with full section properties:

b = 450.00

d = 907.00

d' = 43.00

v = 0.0015437

N = 20792.022

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01151713

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01151713

we (5.4c) = 0.04017143

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773

ase1 = Max(((Aconf,max1 - AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773

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.

$A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.

$A_{noconf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noconf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noconf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.48363$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.97078$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$ ((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 $fs1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$

with $Es1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,

For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 694.45$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, 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.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.07936942$$

$$2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.07936942$$

$$v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.09471283$$

$$2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.09471283$$

$$v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.8) = 0.2570428$$

$$M_u = M_{Rc} (4.15) = 2.5424E+009$$

$$u = s_u (4.1) = 4.7487455E-005$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of M_{u2} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$M_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09471283

2 = Asl,com/(b*d)*(fs2/fc) = 0.09471283

v = Asl,mid/(b*d)*(fsv/fc) = 0.2222852

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.8) = 0.2570428

Mu = MRc (4.15) = 2.5424E+009

$$u = su(4.1) = 4.7487455E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.6067E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.6067E+006$

$V_{r1} = V_{Col}((10.3), \text{ASCE 41-17}) = knl * V_{Col0}$

$$V_{Col0} = 1.6067E+006$$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1.22925$$

$$V_u = 1.5362867E-036$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.022$$

$$A_g = 427500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{sjacket} + V_{s,core} = 1.1114E+006$$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 977392.20$$

$V_{sj1} = 314161.779$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$$s/d = 0.27777778$$

$V_{sj2} = 663230.422$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col_{c1} = 0.00$

$$s/d = 1.25$$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col_{c2} = 1.00$

$$s/d = 0.41666667$$

$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.6067E+006$

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 1.6067E+006

kn1 = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.22925

Vu = 1.5362867E-036

d = 0.8*h = 760.00

Nu = 20792.022

Ag = 427500.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.1114E+006

where:

Vs,jacket = Vs,j1 + Vs,j2 = 977392.20

Vs,j1 = 314161.779 is calculated for section web jacket, with:

d = 360.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs,j1 is multiplied by Col,j1 = 1.00

s/d = 0.27777778

Vs,j2 = 663230.422 is calculated for section flange jacket, with:

d = 760.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs,j2 is multiplied by Col,j2 = 1.00

s/d = 0.13157895

Vs,core = Vs,c1 + Vs,c2 = 134042.359

Vs,c1 = 0.00 is calculated for section web core, with:

d = 200.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs,c1 is multiplied by Col,c1 = 0.00

s/d = 1.25

Vs,c2 = 134042.359 is calculated for section flange core, with:

d = 600.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs,c2 is multiplied by Col,c2 = 1.00

s/d = 0.41666667

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 1.3051E+006

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $E_{cc} = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d > 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 212176.02$
Shear Force, $V_2 = 7994.629$
Shear Force, $V_3 = -107.5573$
Axial Force, $F = -21698.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1539.38$
-Compression: $A_{sc,com} = 1539.38$
-Middle: $A_{sc,mid} = 3612.832$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten,jacket} = 1231.504$
-Compression: $A_{sc,com,jacket} = 1231.504$
-Middle: $A_{sc,mid,jacket} = 2689.203$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten,core} = 307.8761$
-Compression: $A_{sc,com,core} = 307.8761$
-Middle: $A_{sc,mid,core} = 923.6282$
Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00284945$
 $u = y + p = 0.00284945$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00042958$ ((4.29), Biskinis Phd))
 $M_y = 1.1980E+009$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.7887E+014$
factor = 0.30

$$A_g = 562500.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$$

$$N = 21698.244$$

$$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 9.2958\text{E}+014$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 4.1203973\text{E}-006$$

$$\text{with } f_y = 555.56$$

$$d = 907.00$$

$$y = 0.25671634$$

$$A = 0.01649063$$

$$B = 0.00868179$$

$$\text{with } p_t = 0.0037716$$

$$p_c = 0.0037716$$

$$p_v = 0.00885172$$

$$N = 21698.244$$

$$b = 450.00$$

$$" = 0.04740904$$

$$y_{\text{comp}} = 9.4777787\text{E}-006$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.25592798$$

$$A = 0.01627411$$

$$B = 0.0085861$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.00241987$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 1.0549$

$$d = d_{\text{external}} = 907.00$$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_f e / f_s) = 0.00427788$$

$$\text{jacket: } s_1 = A_{v1} \cdot L_{\text{stir}1} / (s_1 \cdot A_g) = 0.00357443$$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir}1} = 2560.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot L_{\text{stir}2} / (s_2 \cdot A_g) = 0.00070345$$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir}2} = 1968.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

The term $2 \cdot t_f / b_w \cdot (f_f e / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and $f_f e / f_s$ normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$N_{UD} = 21698.244$$

$$A_g = 562500.00$$

$$f_c E = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{section}_{\text{area}} = 33.00$$

$$f_y E = (f_y_{\text{ext_Long_Reinf}} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_y_{\text{int_Long_Reinf}} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 555.56$$

$$f_{yt} E = (f_y_{\text{ext_Trans_Reinf}} \cdot s_1 + f_y_{\text{int_Trans_Reinf}} \cdot s_2) / (s_1 + s_2) = 555.56$$

$$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01639493$$

$$b = 450.00$$

d = 907.00
f_{cE} = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

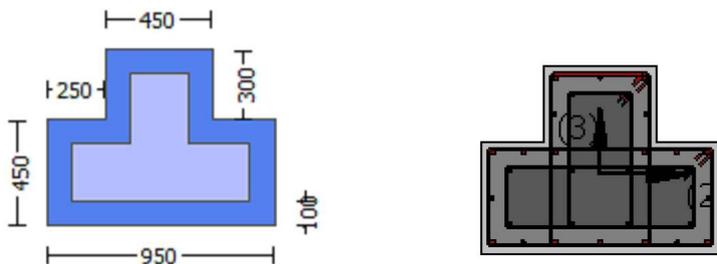
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d >= 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.5457E+007$

Shear Force, $V_a = -5106.265$

EDGE -B-

Bending Moment, $M_b = 135519.787$

Shear Force, $V_b = 5106.265$

BOTH EDGES

Axial Force, $F = -21370.837$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1539.38$

-Compression: $A_{st,com} = 1539.38$

-Middle: $A_{st,mid} = 3612.832$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 1.2171E+006$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 1.2171E+006$

$V_{CoI} = 1.2171E+006$

$k_n = 1.00$

displacement_ductility_demand = 0.00762722

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} <= 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 3.98305$

$M_u = 1.5457E+007$

$V_u = 5106.265$

$d = 0.8 \cdot h = 760.00$
 $Nu = 21370.837$
 $Ag = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.0003E+006$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 879645.943$
 $V_{s,j1} = 282743.339$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{s,j2} = 596902.604$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 120637.158$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 120637.158$ is calculated for section flange core, with:
 $d = 600.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.1360E+006$
 $bw = 450.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation $\theta = 3.3057731E-005$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00433418$ ((4.29), Biskinis Phd))
 $M_y = 1.1979E+009$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3027.121
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.7887E+014$
 $factor = 0.30$
 $Ag = 562500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$
 $N = 21370.837$
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 9.2958E+014$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.1202810E-006$
 with $f_y = 555.56$
 $d = 907.00$

$y = 0.25669535$
 $A = 0.01648918$
 $B = 0.00868035$
 with $pt = 0.0037716$
 $pc = 0.0037716$
 $pv = 0.00885172$
 $N = 21370.837$
 $b = 450.00$
 $" = 0.04740904$
 $y_{comp} = 9.4781187E-006$
 with $fc = 33.00$
 $E_c = 26999.444$
 $y = 0.2559188$
 $A = 0.01627594$
 $B = 0.0085861$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

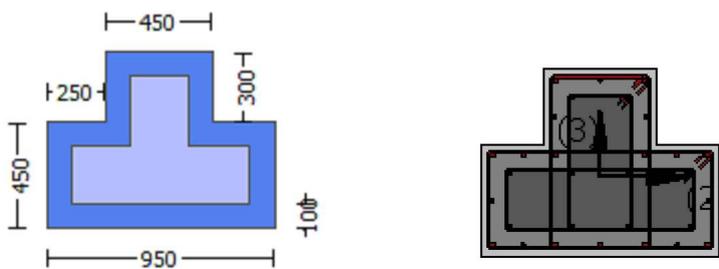
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -2.5090294E-020$

EDGE -B-

Shear Force, $V_b = 2.5090294E-020$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1539.38$

-Compression: $A_{sl,com} = 2475.575$

-Middle: $A_{sl,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.03465$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$

with
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 2.0610E+009$
 $\mu_{1+} = 1.9075E+009$, 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
 $\mu_{1-} = 2.0610E+009$, 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
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 2.0610E+009$
 $\mu_{2+} = 1.9075E+009$, 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
 $\mu_{2-} = 2.0610E+009$, 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:

$\mu = 5.2259729E-005$
 $M_u = 1.9075E+009$

 with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.022$
 $f_c = 33.00$
 $\alpha (5A.5, \text{TB DY}) = 0.002$
 Final value of μ_c : $\mu_c^* = \text{shear_factor} * \text{Max}(\mu_c, \alpha) = 0.01151713$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TB DY: $\mu_c = 0.01151713$

$w_e (5.4c) = 0.04017143$
 $a_{se} ((5.4d), \text{TB DY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$
 $a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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.
 $A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$
 $p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.97078
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00357443
Lstir₁ (Length of stirrups along X) = 2560.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00070345
Lstir₂ (Length of stirrups along X) = 1968.00
Astir₂ (stirrups area) = 50.26548

Asec = 562500.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.45

fywe₂ = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 833.34

fy₁ = 694.45

su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su₁ = 0.4*esu_{1_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{1_nominal} = 0.08,

For calculation of esu_{1_nominal} and y₁, sh₁,ft₁,fy₁, it is considered
characteristic value fsy₁ = fs₁/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₁ = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es₁ = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y₂ = 0.0025

sh₂ = 0.008

ft₂ = 833.34

fy₂ = 694.45

su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su₂ = 0.4*esu_{2_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{2_nominal} = 0.08,

For calculation of esu_{2_nominal} and y₂, sh₂,ft₂,fy₂, it is considered
characteristic value fsy₂ = fs₂/1.2, from table 5.1, TBDY.

y₂, sh₂,ft₂,fy₂, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es₂ = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

y_v = 0.0025

sh_v = 0.008

ft_v = 833.34

fy_v = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value 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 = 694.45

with Es_v = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs₁/fc) = 0.04823141

$$2 = A_{sl,com}/(b*d)^*(f_{s2}/f_c) = 0.07756398$$

$$v = A_{sl,mid}/(b*d)^*(f_{sv}/f_c) = 0.0838636$$

and confined core properties:

$$b = 890.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten}/(b*d)^*(f_{s1}/f_c) = 0.05376434$$

$$2 = A_{sl,com}/(b*d)^*(f_{s2}/f_c) = 0.08646184$$

$$v = A_{sl,mid}/(b*d)^*(f_{sv}/f_c) = 0.09348412$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.8) = 0.13390923$$

$$\mu_u = M_{Rc} (4.15) = 1.9075E+009$$

$$u = s_u (4.1) = 5.2259729E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{u1} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.5076774E-005$$

$$\mu_u = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e (5.4c) = 0.04017143$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$
 $c = \text{confinement factor} = 1.22443$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou_{min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou_{min} = lb/lb_{min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu2_{nominal} = 0.08$,

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

with $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$

$shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$
 with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537$
 and confined core properties:
 $b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.19731035$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.12269298$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.21333555$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs,y2$ - LHS eq.(4.5) is not satisfied
 --->
 $v < vs,c$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.30448812$
 $Mu = MRc (4.15) = 2.0610E+009$
 $u = su (4.1) = 6.5076774E-005$

 Calculation of ratio lb/ld

 Adequate Lap Length: $lb/ld \geq 1$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 5.2259729E-005$
 $Mu = 1.9075E+009$

 with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.022$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01151713$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01151713$
 $we (5.4c) = 0.04017143$

$$ase \ ((5.4d), \text{TB DY}) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 \ (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{,min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$$

$$psh1 \ ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \ (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$$

$$psh1 \ ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \ ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.A5), \text{TB DY}), \text{TB DY: } cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{,min} = lb/ld = 1.00$$

$$su1 = 0.4 * esu1_{nominal} \ ((5.5), \text{TB DY}) = 0.032$$

From table 5A.1, TB DY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1$, $sh1$, $ft1$, $fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TB DY.

$y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$$

$$\text{with } Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$$

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141

2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398

v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636

and confined core properties:

b = 890.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434

2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184

v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.8) = 0.13390923

Mu = MRc (4.15) = 1.9075E+009

u = su (4.1) = 5.2259729E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.5076774E-005$$

$$Mu = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\phi_{we} \text{ (5.4c)} = 0.04017143$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (> = \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424426$$

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619

2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187

v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537

and confined core properties:

b = 390.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.19731035

2 = Asl,com/(b*d)*(fs2/fc) = 0.12269298

v = Asl,mid/(b*d)*(fsv/fc) = 0.21333555

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 μ (4.8) = 0.30448812
 $\mu_u = MR_c$ (4.15) = 2.0610E+009
 $u = \mu$ (4.1) = 6.5076774E-005

 Calculation of ratio l_b/l_d

 Adequate Lap Length: $l_b/l_d \geq 1$

 Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.3280E+006$

 Calculation of Shear Strength at edge 1, $V_{r1} = 1.3280E+006$
 $V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{Col0}$
 $V_{Col0} = 1.3280E+006$
 $k_{nl} = 1$ (zero step-static loading)

 NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c \cdot \text{Area}_{jacket} + f'_c \cdot \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/d = 2.00$
 $\mu_u = 1534.018$
 $V_u = 2.5090294E-020$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 20792.022$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 936062.473$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$
 $V_{s,j1} = 523602.964$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$
 $V_{s,c1} = 98297.73$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$
 $s/d = 1.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 1.3280E+006$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1534.018$

$V_u = 2.5090294E-020$

$d = 0.8 * h = 600.00$

$N_u = 20792.022$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 936062.473$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 837764.743$

$V_{sj1} = 523602.964$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$s/d = 0.16666667$

$V_{sj2} = 314161.779$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$s/d = 0.27777778$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col_{c1} = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col_{c2} = 0.00$

$s/d = 1.25$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$

$bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $k = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.5362867E-036$

EDGE -B-

Shear Force, $V_b = -1.5362867E-036$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, ten} = 1539.38$

-Compression: $A_{sc, com} = 1539.38$

-Middle: $A_{st, mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.0549$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6949E+006$

with

$$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.5424E+009$$

$M_{u1+} = 2.5424E+009$, 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

$M_{u1-} = 2.5424E+009$, 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

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.5424E+009$$

$M_{u2+} = 2.5424E+009$, 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

$M_{u2-} = 2.5424E+009$, 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:

$$\phi_u = 4.7487455E-005$$

$$M_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\phi_{ue} (5.4c) = 0.04017143$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

psh_y*F_{ywe} = psh₁*F_{ywe1}+ps₂*F_{ywe2} = 2.97078
psh₁ ((5.4d), TBDY) = L_{stir1}*A_{stir1}/(A_{sec}*s₁) = 0.00357443
L_{stir1} (Length of stirrups along X) = 2560.00
A_{stir1} (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = L_{stir2}*A_{stir2}/(A_{sec}*s₂) = 0.00070345
L_{stir2} (Length of stirrups along X) = 1968.00
A_{stir2} (stirrups area) = 50.26548

A_{sec} = 562500.00

s₁ = 100.00

s₂ = 250.00

f_{ywe1} = 694.45

f_{ywe2} = 694.45

f_{ce} = 33.00

From ((5.A5), TBDY), TBDY: c_c = 0.00424426

c = confinement factor = 1.22443

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 833.34

fy₁ = 694.45

su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su₁ = 0.4*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 fs_{y1} = fs₁/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₁ = (fs_{jacket}*A_{sl,ten,jacket} + fs_{core}*A_{sl,ten,core})/A_{sl,ten} = 694.45

with Es₁ = (Es_{jacket}*A_{sl,ten,jacket} + Es_{core}*A_{sl,ten,core})/A_{sl,ten} = 200000.00

y₂ = 0.0025

sh₂ = 0.008

ft₂ = 833.34

fy₂ = 694.45

su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su₂ = 0.4*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 fs_{y2} = fs₂/1.2, from table 5.1, TBDY.

y₂, sh₂,ft₂,fy₂, are also multiplied by Min(1,1.25*(lb/d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = (fs_{jacket}*A_{sl,com,jacket} + fs_{core}*A_{sl,com,core})/A_{sl,com} = 694.45

with Es₂ = (Es_{jacket}*A_{sl,com,jacket} + Es_{core}*A_{sl,com,core})/A_{sl,com} = 200000.00

y_v = 0.0025

sh_v = 0.008

ft_v = 833.34

fy_v = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4*esuv_{nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_{nominal} = 0.08,

considering characteristic value fs_{yv} = fs_v/1.2, from table 5.1, TBDY

For calculation of esuv_{nominal} and y_v, sh_v,ft_v,fy_v, it is considered
characteristic value fs_{yv} = fs_v/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by 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} = 694.45

with Es_v = (Es_{jacket}*A_{sl,mid,jacket} + Es_{mid}*A_{sl,mid,core})/A_{sl,mid} = 200000.00

1 = A_{sl,ten}/(b*d)*(fs₁/f_c) = 0.07936942

2 = A_{sl,com}/(b*d)*(fs₂/f_c) = 0.07936942

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09471283$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09471283$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.8) = 0.2570428$$

$$\mu_u = M R_c (4.15) = 2.5424E+009$$

$$u = s_u (4.1) = 4.7487455E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{u1} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$\mu_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e (5.4c) = 0.04017143$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$
 $s_1 = 100.00$
 $s_2 = 250.00$

$f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00424426$
 $c = \text{confinement factor} = 1.22443$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * esu1_{nominal} ((5.5), \text{TBDY}) = 0.032$

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 $fsy_1 = fs_1/1.2$, 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 $fs_1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with $Es_1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

$su_2 = 0.4 * esu2_{nominal} ((5.5), \text{TBDY}) = 0.032$

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 $fs_2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

with $Es_2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.0025$
 $sh_v = 0.008$

$f_{tv} = 833.34$
 $f_{yv} = 694.45$
 $s_{uv} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
 considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv_nominal}$ and 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{s,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $E_{sv} = (E_{s,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.07936942$
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.07936942$
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.18627516$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.09471283$
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.09471283$
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.2222852$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->
 $su (4.8) = 0.2570428$
 $Mu = MRc (4.15) = 2.5424E+009$
 $u = su (4.1) = 4.7487455E-005$

 Calculation of ratio l_b/l_d

 Adequate Lap Length: $l_b/l_d \geq 1$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 4.7487455E-005$
 $Mu = 2.5424E+009$

 with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.022$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01151713$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01151713$
 $w_e (5.4c) = 0.04017143$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1) * (Aconf,min1/Aconf,max1), 0) = 0.53375773$$

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 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.53375773$$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.48363$$

$$psh,x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.48363$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh,y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2560.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1968.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 694.45$$

$$\text{with } Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered
characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 694.45$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv , shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$$

$$\text{with } Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07936942$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07936942$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09471283$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.09471283$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.2570428$$

$$Mu = MRc (4.15) = 2.5424E+009$$

$$u = su (4.1) = 4.7487455E-005$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$\mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$\omega (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\omega_e (5.4c) = 0.04017143$$

$$\text{ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.53375773$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{ase2} (>= \text{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{psh}_{min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 2.48363$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.48363$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$\text{psh}_2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.97078$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$\text{psh}_2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09471283

2 = Asl,com/(b*d)*(fs2/fc) = 0.09471283

v = Asl,mid/(b*d)*(fsv/fc) = 0.2222852

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

$$\mu (4.8) = 0.2570428$$

$$\mu = M/R_c (4.15) = 2.5424E+009$$

$$u = \mu (4.1) = 4.7487455E-005$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.6067E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.6067E+006$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 1.6067E+006$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

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: $f'_c = (f'_c \text{ jacket} * \text{Area jacket} + f'_c \text{ core} * \text{Area core}) / \text{Area section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu = 1.22925$$

$$V_u = 1.5362867E-036$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.022$$

$$A_g = 427500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{sjacket} + V_{s,core} = 1.1114E+006$$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 977392.20$$

$V_{sj1} = 314161.779$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$$s/d = 0.27777778$$

$V_{sj2} = 663230.422$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col_{c1} = 0.00$

$$s/d = 1.25$$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col_{c2} = 1.00$

$$s/d = 0.41666667$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.3051E+006$$

bw = 450.00

Calculation of Shear Strength at edge 2, $Vr2 = 1.6067E+006$
 $Vr2 = VCol$ ((10.3), ASCE 41-17) = $knl * VCol0$
 $VCol0 = 1.6067E+006$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $Vs = Av * fy * d / s$ ' is replaced by ' $Vs + Vf$ '
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$, but $fc'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 1.22925$
 $Vu = 1.5362867E-036$
 $d = 0.8 * h = 760.00$
 $Nu = 20792.022$
 $Ag = 427500.00$
From (11.5.4.8), ACI 318-14: $Vs = Vs_{jacket} + Vs_{core} = 1.1114E+006$
where:
 $Vs_{jacket} = Vs_{j1} + Vs_{j2} = 977392.20$
 $Vs_{j1} = 314161.779$ is calculated for section web jacket, with:
 $d = 360.00$
 $Av = 157079.633$
 $fy = 555.56$
 $s = 100.00$
 Vs_{j1} is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.27777778$
 $Vs_{j2} = 663230.422$ is calculated for section flange jacket, with:
 $d = 760.00$
 $Av = 157079.633$
 $fy = 555.56$
 $s = 100.00$
 Vs_{j2} is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.13157895$
 $Vs_{core} = Vs_{c1} + Vs_{c2} = 134042.359$
 $Vs_{c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $Av = 100530.965$
 $fy = 555.56$
 $s = 250.00$
 Vs_{c1} is multiplied by $Col_{c1} = 0.00$
 $s/d = 1.25$
 $Vs_{c2} = 134042.359$ is calculated for section flange core, with:
 $d = 600.00$
 $Av = 100530.965$
 $fy = 555.56$
 $s = 250.00$
 Vs_{c2} is multiplied by $Col_{c2} = 1.00$
 $s/d = 0.41666667$
 Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $Vs + Vf \leq 1.3051E+006$
 $bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\phi = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d > 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -133381.819$

Shear Force, $V_2 = -5106.265$

Shear Force, $V_3 = 68.69811$

Axial Force, $F = -21370.837$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1539.38$

-Compression: $A_{st,com} = 2475.575$

-Middle: $A_{st,mid} = 2676.637$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten,jacket} = 1231.504$

-Compression: $A_{st,com,jacket} = 1859.823$

-Middle: $A_{st,mid,jacket} = 2060.885$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten,core} = 307.8761$

-Compression: $A_{st,com,core} = 615.7522$

-Middle: $A_{st,mid,core} = 615.7522$

Mean Diameter of Tension Reinforcement, $D_{bL} = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.0455326$

$u = \gamma + \rho = 0.0455326$

- Calculation of γ -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00307028$ ((4.29), Biskinis Phd))

$$M_y = 8.7053E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1*L \text{ and } L_s < 2*L) = 1941.565$$

$$\text{From table 10.5, ASCE 41_17: } E_{\text{eff}} = \text{factor} * E_c * I_g = 1.8350E+014$$

$$\text{factor} = 0.30$$

$$A_g = 562500.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$$

$$N = 21370.837$$

$$E_c * I_g = E_{c,\text{jacket}} * I_{g,\text{jacket}} + E_{c,\text{core}} * I_{g,\text{core}} = 6.1166E+014$$

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:

$$\text{flange width, } b = 950.00$$

$$\text{web width, } b_w = 450.00$$

$$\text{flange thickness, } t = 450.00$$

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 4.9084537E-006$$

$$\text{with } f_y = 555.56$$

$$d = 707.00$$

$$y = 0.19954511$$

$$A = 0.01002019$$

$$B = 0.00468716$$

$$\text{with } p_t = 0.00229194$$

$$p_c = 0.00368581$$

$$p_v = 0.00398517$$

$$N = 21370.837$$

$$b = 950.00$$

$$" = 0.06082037$$

$$y_{\text{comp}} = 1.5661541E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.19869078$$

$$A = 0.0098906$$

$$B = 0.00462988$$

$$\text{with } E_s = 200000.00$$

CONFIRMATION: $y = 0.19954511 < t/d$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.04246232$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$

$$\text{shear control ratio } V_y E / V_{\text{col}} E = 1.03465$$

$$d = d_{\text{external}} = 707.00$$

$$s = s_{\text{external}} = 0.00$$

$$- t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.0035764$$

$$\text{jacket: } s_1 = A_{v1} * L_{\text{stir1}} / (s_1 * A_g) = 0.00301593$$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2160.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * L_{\text{stir2}} / (s_2 * A_g) = 0.00056047$$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1568.00$, 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.

$$N_{UD} = 21370.837$$

$$A_g = 562500.00$$

$$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 33.00$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 555.56$$

$$f_{ytE} = (f_{y_ext_Trans_Reinf} \cdot s_1 + f_{y_int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$$

$$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.00996292$$

$$b = 950.00$$

$$d = 707.00$$

$$f_{cE} = 33.00$$

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

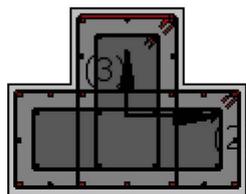
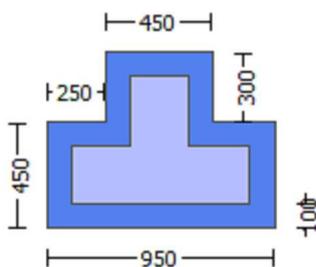
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

```

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of  $\mu_y$  for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
#####
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment, Ma = -133381.819
Shear Force, Va = 68.69811
EDGE -B-
Bending Moment, Mb = -72101.197
Shear Force, Vb = -68.69811
BOTH EDGES
Axial Force, F = -21370.837
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143
-----
-----

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 1.0537E+006
Vn ((10.3), ASCE 41-17) = knl*VColO = 1.0537E+006
VCol = 1.0537E+006
knl = 1.00
displacement_ductility_demand = 0.00239734

```

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 3.23594$

$\mu_u = 133381.819$

$V_u = 68.69811$

$d = 0.8 \cdot h = 600.00$

$N_u = 21370.837$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 842449.486$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 753982.237$

$V_{s,j1} = 471238.898$ 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 $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 282743.339$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.27777778$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 88467.249$

$V_{s,c1} = 88467.249$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 0.00$

$s/d = 1.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 896810.169$

$b_w = 450.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 7.3605164E-006$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00307028$ ((4.29), Biskinis Phd)

$M_y = 8.7053E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1941.565

From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 1.8350E+014$

factor = 0.30

$A_g = 562500.00$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$

$N = 21370.837$

$E_c \cdot I_g = E_c \cdot I_{g,\text{jacket}} + E_c \cdot I_{g,\text{core}} = 6.1166E+014$

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, $b = 950.00$

web width, $b_w = 450.00$

flange thickness, $t = 450.00$

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$

$y_{\text{ten}} = 4.9084537\text{E-}006$

with $f_y = 555.56$

$d = 707.00$

$y = 0.19954511$

$A = 0.01002019$

$B = 0.00468716$

with $p_t = 0.00229194$

$p_c = 0.00368581$

$p_v = 0.00398517$

$N = 21370.837$

$b = 950.00$

" = 0.06082037

$y_{\text{comp}} = 1.5661541\text{E-}005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19869078$

$A = 0.0098906$

$B = 0.00462988$

with $E_s = 200000.00$

CONFIRMATION: $y = 0.19954511 < t/d$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

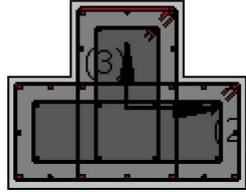
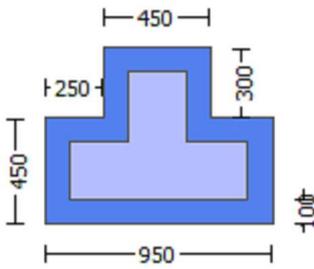
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{o,min} >= 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -2.5090294E-020$

EDGE -B-

Shear Force, $V_b = 2.5090294E-020$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1539.38$

-Compression: $As_{c,com} = 2475.575$

-Middle: $As_{c,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.03465$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.0610E+009$

$Mu_{1+} = 1.9075E+009$, 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

$Mu_{1-} = 2.0610E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.0610E+009$

$Mu_{2+} = 1.9075E+009$, 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

$Mu_{2-} = 2.0610E+009$, 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:

$\phi_u = 5.2259729E-005$

$Mu = 1.9075E+009$

with full section properties:

$b = 950.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093808$

$N = 20792.022$

$f_c = 33.00$

α_{co} (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01151713$

ϕ_{we} (5.4c) = 0.04017143

ϕ_{ase} ((5.4d), TBDY) = $(\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$

$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{ase2} (>= \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$
 $c = \text{confinement factor} = 1.22443$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with $Es1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$ ((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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

with $Es2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$

$shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$
 with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636$
 and confined core properties:
 $b = 890.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs,y2$ - LHS eq.(4.5) is not satisfied
 --->
 $v < vs,c$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.13390923$
 $Mu = MRc (4.15) = 1.9075E+009$
 $u = su (4.1) = 5.2259729E-005$

 Calculation of ratio lb/ld

 Adequate Lap Length: $lb/ld \geq 1$

Calculation of $Mu1$ -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 6.5076774E-005$
 $Mu = 2.0610E+009$

 with full section properties:

$b = 450.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00198039$
 $N = 20792.022$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01151713$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01151713$
 $we (5.4c) = 0.04017143$

$$ase \ ((5.4d), \text{TB DY}) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 \ (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{,min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.48363$$

$$psh1 \ ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \ (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.97078$$

$$psh1 \ ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \ ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.A5), \text{TB DY}), \text{TB DY: } cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou_{,min} = lb/d = 1.00$$

$$su1 = 0.4 * esu1_{nominal} \ ((5.5), \text{TB DY}) = 0.032$$

From table 5A.1, TB DY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1$, $sh1$, $ft1$, $fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TB DY.

$y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$$

$$\text{with } Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$$

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619

2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187

v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537

and confined core properties:

b = 390.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.19731035

2 = Asl,com/(b*d)*(fs2/fc) = 0.12269298

v = Asl,mid/(b*d)*(fsv/fc) = 0.21333555

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.8) = 0.30448812

Mu = MRc (4.15) = 2.0610E+009

u = su (4.1) = 6.5076774E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 5.2259729E-005$$

$$Mu = 1.9075E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\phi_{we} \text{ (5.4c)} = 0.04017143$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (> \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424426$$

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141

2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398

v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636

and confined core properties:

b = 890.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434

2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184

v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u(4.8) = 0.13390923$$

$$\mu_u = MR_c(4.15) = 1.9075E+009$$

$$u = s_u(4.1) = 5.2259729E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_u

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.5076774E-005$$

$$\mu_u = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_u = 0.01151713$$

$$w_e(5.4c) = 0.04017143$$

$$a_{se}(5.4d, TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1}(5.4d, TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1}(\text{Length of stirrups along Y}) = 2160.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$p_{sh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2}(\text{Length of stirrups along Y}) = 1568.00$$

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 2.97078
psh₁ ((5.4d), TBDY) = Lstir₁*Astir₁/(Asec*s₁) = 0.00357443
Lstir₁ (Length of stirrups along X) = 2560.00
Astir₁ (stirrups area) = 78.53982
psh₂ ((5.4d), TBDY) = Lstir₂*Astir₂/(Asec*s₂) = 0.00070345
Lstir₂ (Length of stirrups along X) = 1968.00
Astir₂ (stirrups area) = 50.26548

Asec = 562500.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.45

fywe₂ = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 833.34

fy₁ = 694.45

su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su₁ = 0.4*esu_{1_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{1_nominal} = 0.08,

For calculation of esu_{1_nominal} and y₁, sh₁,ft₁,fy₁, it is considered
characteristic value fsy₁ = fs₁/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₁ = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es₁ = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y₂ = 0.0025

sh₂ = 0.008

ft₂ = 833.34

fy₂ = 694.45

su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su₂ = 0.4*esu_{2_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{2_nominal} = 0.08,

For calculation of esu_{2_nominal} and y₂, sh₂,ft₂,fy₂, it is considered
characteristic value fsy₂ = fs₂/1.2, from table 5.1, TBDY.

y₂, sh₂,ft₂,fy₂, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es₂ = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

y_v = 0.0025

sh_v = 0.008

ft_v = 833.34

fy_v = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsy_v = fs_v/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and y_v, sh_v,ft_v,fy_v, it is considered
characteristic value fsy_v = fs_v/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fs_v = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Es_v = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.16374619$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10182187$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17704537$$

and confined core properties:

$$b = 390.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19731035$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12269298$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21333555$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.8) = 0.30448812$$

$$M_u = M_{Rc} (4.15) = 2.0610E+009$$

$$u = s_u (4.1) = 6.5076774E-005$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.3280E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.3280E+006$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$$V_{Col0} = 1.3280E+006$$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$M_u = 1534.018$$

$$V_u = 2.5090294E-020$$

$$d = 0.8 * h = 600.00$$

$$N_u = 20792.022$$

$$A_g = 337500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 936062.473$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 837764.743$$

$V_{sj1} = 523602.964$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj1} is multiplied by $Col,j1 = 1.00$

$$s/d = 0.16666667$$

$V_{sj2} = 314161.779$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

V_{sj2} is multiplied by $Col,j2 = 1.00$

$s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$
 $V_{s,c1} = 98297.73$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 1.3280E+006$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 33.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu_u = 1534.018$
 $V_u = 2.5090294E-020$
 $d = 0.8 * h = 600.00$
 $N_u = 20792.022$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 936062.473$
 where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$
 $V_{s,j1} = 523602.964$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$
 $V_{s,c1} = 98297.73$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 555.56$

s = 250.00
Vs,c2 is multiplied by Col,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 1.0304E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:

Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45

#####

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.22443
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5362867E-036
EDGE -B-
Shear Force, Vb = -1.5362867E-036

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{,ten} = 1539.38$

-Compression: $As_{,com} = 1539.38$

-Middle: $As_{,mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.0549$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6949E+006$

with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.5424E+009$
 $Mu_{1+} = 2.5424E+009$, 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
 $Mu_{1-} = 2.5424E+009$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.5424E+009$
 $Mu_{2+} = 2.5424E+009$, 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
 $Mu_{2-} = 2.5424E+009$, 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:

$\phi_u = 4.7487455E-005$

$M_u = 2.5424E+009$

with full section properties:

$b = 450.00$

$d = 907.00$

$d' = 43.00$

$v = 0.0015437$

$N = 20792.022$

$f_c = 33.00$

$\omega (5A.5, TBDY) = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01151713$

$\omega_e (5.4c) = 0.04017143$

$\omega_{ase} ((5.4d), TBDY) = (\omega_{ase1} * A_{ext} + \omega_{ase2} * A_{int}) / A_{sec} = 0.53375773$

$\omega_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\omega_{ase2} (>= \omega_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$
 $p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$

$f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00424426$
 c = confinement factor = 1.22443

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with $Es1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

$su2 = 0.4 * esu2_{nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $esu2_{nominal} = 0.08$,

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

with $Es2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$
 $shv = 0.008$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv , shv , ftv , fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$$

$$\text{with } Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.07936942$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.07936942$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.09471283$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.09471283$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs_{y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < vs_c$ - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.2570428$$

$$Mu = MRc (4.15) = 2.5424E+009$$

$$u = su (4.1) = 4.7487455E-005$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$Mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01151713$$

$$we (5.4c) = 0.04017143$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.53375773$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1) * (Aconf,min1/Aconf,max1), 0) = 0.53375773$$

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 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).

$$ase2 (\geq ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.53375773$$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $bi^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.48363$$

$$psh,x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.48363$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh,y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2560.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1968.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 694.45$$

$$\text{with } Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 694.45$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$$

$$\text{with } Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07936942$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07936942$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09471283$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.09471283$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.2570428$$

$$Mu = MRc (4.15) = 2.5424E+009$$

$$u = su (4.1) = 4.7487455E-005$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_{2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$\mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$\omega (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\omega_e (5.4c) = 0.04017143$$

$$\text{ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.53375773$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{ase2} (>= \text{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{psh}_{min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 2.48363$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.48363$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\text{psh}_2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.97078$$

$$\text{psh}_1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\text{psh}_2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09471283

2 = Asl,com/(b*d)*(fs2/fc) = 0.09471283

v = Asl,mid/(b*d)*(fsv/fc) = 0.2222852

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u(4.8) = 0.2570428$$

$$\mu_u = M_{Rc}(4.15) = 2.5424E+009$$

$$u = s_u(4.1) = 4.7487455E-005$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_u

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$\mu_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$\alpha(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_u = 0.01151713$$

$$\mu_{we}(5.4c) = 0.04017143$$

$$\mu_{ase}((5.4d), \text{TBDY}) = (\alpha_1 * A_{ext} + \alpha_2 * A_{int}) / A_{sec} = 0.53375773$$

$$\alpha_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\alpha_2 (\geq \alpha_1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\text{psh}_{min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 2.48363$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.48363$$

$$\text{psh}_1((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1}(\text{Length of stirrups along } Y) = 2160.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$\text{psh}_2(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2}(\text{Length of stirrups along } Y) = 1568.00$$

$$A_{stir2}(\text{stirrups area}) = 50.26548$$

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07936942$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09471283$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09471283$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.8) = 0.2570428$$

$$\mu_u = M/R_c (4.15) = 2.5424E+009$$

$$u = s_u (4.1) = 4.7487455E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.6067E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.6067E+006$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 1.6067E+006$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$, but $f_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1.22925$$

$$V_u = 1.5362867E-036$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.022$$

$$A_g = 427500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 1.1114E+006$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977392.20$$

$V_{s,j1} = 314161.779$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

$$s/d = 0.27777778$$

$V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

$$s/d = 1.25$$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

$$s/d = 0.41666667$$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.6067E+006$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$$V_{Col0} = 1.6067E+006$$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1.22925$$

$$V_u = 1.5362867E-036$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.022$$

$$A_g = 427500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.1114E+006$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977392.20$$

$V_{s,j1} = 314161.779$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

$V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

$$s/d = 0.27777778$$

$V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

$$s/d = 1.25$$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

V_{s,c2} is multiplied by Col,c2 = 1.00
s/d = 0.41666667
V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: V_s + V_f <= 1.3051E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, f_c = f_{cm} = 33.00

New material of Primary Member: Steel Strength, f_s = f_{sm} = 555.56

Concrete Elasticity, E_c = 26999.444

Steel Elasticity, E_s = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, f_c = f_{cm} = 33.00

New material of Primary Member: Steel Strength, f_s = f_{sm} = 555.56

Concrete Elasticity, E_c = 26999.444

Steel Elasticity, E_s = 200000.00

Max Height, H_{max} = 750.00

Min Height, H_{min} = 450.00

Max Width, W_{max} = 950.00

Min Width, W_{min} = 450.00

Eccentricity, Ecc = 250.00

Jacket Thickness, t_j = 100.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (l_b/l_d >= 1)

No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.5457E+007

Shear Force, V₂ = -5106.265

Shear Force, V₃ = 68.69811

Axial Force, F = -21370.837

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: A_{sl,t} = 0.00

-Compression: A_{sl,c} = 6691.592

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: A_{sl,ten} = 1539.38

-Compression: A_{sl,com} = 1539.38

-Middle: A_{sl,mid} = 3612.832

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: A_{sl,ten,jacket} = 1231.504

-Compression: A_{sl,com,jacket} = 1231.504

-Middle: $Asl_{mid,jacket} = 2689.203$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten,core} = 307.8761$

-Compression: $Asl_{com,core} = 307.8761$

-Middle: $Asl_{mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04929644$

$u = y + p = 0.04929644$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00433418$ ((4.29), Biskinis Phd)

$My = 1.1979E+009$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 3027.121

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 2.7887E+014$

factor = 0.30

$Ag = 562500.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 21370.837$

$Ec * Ig = Ec_{jacket} * Ig_{jacket} + Ec_{core} * Ig_{core} = 9.2958E+014$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 4.1202810E-006$

with $fy = 555.56$

$d = 907.00$

$y = 0.25669535$

$A = 0.01648918$

$B = 0.00868035$

with $pt = 0.0037716$

$pc = 0.0037716$

$pv = 0.00885172$

$N = 21370.837$

$b = 450.00$

$" = 0.04740904$

$y_{comp} = 9.4781187E-006$

with $fc = 33.00$

$Ec = 26999.444$

$y = 0.2559188$

$A = 0.01627594$

$B = 0.0085861$

with $Es = 200000.00$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.04496226$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/d \geq 1$

shear control ratio $VyE/VCoIE = 1.0549$

$d = d_{external} = 907.00$

$s = s_{external} = 0.00$

$$- t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00427788$$

$$\text{jacket: } s1 = Av1*Lstir1/(s1*Ag) = 0.00357443$$

Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction

Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction

$$s1 = 100.00$$

$$\text{core: } s2 = Av2*Lstir2/(s2*Ag) = 0.00070345$$

Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction

Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction

$$s2 = 250.00$$

The term $2*tf/bw*(ffe/fs)$ is implemented to account for FRP contribution

where $f = 2*tf/bw$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation fs of jacket is used.

$$NUD = 21370.837$$

$$Ag = 562500.00$$

$$fcE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00$$

$$fyIE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56$$

$$fytE = (fy_ext_Trans_Reinf* s1+fy_int_Trans_Reinf* s2)/(s1+ s2) = 555.56$$

$$pl = Area_Tot_Long_Rein/(b*d) = 0.01639493$$

$$b = 450.00$$

$$d = 907.00$$

$$fcE = 33.00$$

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

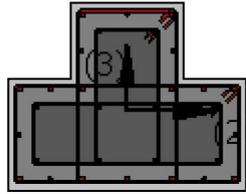
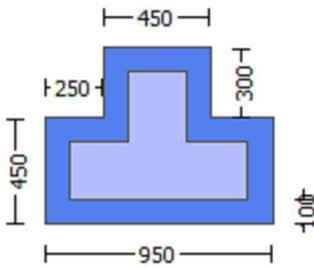
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{o,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.5457E+007$
Shear Force, $V_a = -5106.265$
EDGE -B-
Bending Moment, $M_b = 135519.787$
Shear Force, $V_b = 5106.265$
BOTH EDGES
Axial Force, $F = -21370.837$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1539.38$
-Compression: $A_{sl,com} = 1539.38$
-Middle: $A_{sl,mid} = 3612.832$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 1.4320E+006$
 V_n ((10.3), ASCE 41-17) = $kn1 \cdot V_{CoIO} = 1.4320E+006$
 $V_{CoI} = 1.4320E+006$
 $kn1 = 1.00$
 $displacement_ductility_demand = 0.01967878$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/d = 2.00$
 $M_u = 135519.787$
 $V_u = 5106.265$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 21370.837$
 $A_g = 427500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.0003E+006$
where:
 $V_{s,jacket} = V_{sj1} + V_{sj2} = 879645.943$
 $V_{sj1} = 282743.339$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj1} is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 596902.604$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj2} is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{sc1} + V_{sc2} = 120637.158$
 $V_{sc1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 V_{sc1} is multiplied by $Col_{c1} = 0.00$
 $s/d = 1.25$
 $V_{sc2} = 120637.158$ is calculated for section flange core, with:
 $d = 600.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 1.1360E+006$
 $bw = 450.00$

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 $\theta = 8.4527170E-006$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00042953$ ((4.29), Biskinis Phd))
 $M_y = 1.1979E+009$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.7887E+014$
factor = 0.30
 $A_g = 562500.00$
Mean concrete strength: $f'_c = (f'_{jacket} * Area_{jacket} + f'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 21370.837$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 9.2958E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.1202810E-006$
with $f_y = 555.56$
 $d = 907.00$
 $y = 0.25669535$
 $A = 0.01648918$
 $B = 0.00868035$
with $p_t = 0.0037716$
 $p_c = 0.0037716$
 $p_v = 0.00885172$
 $N = 21370.837$
 $b = 450.00$
 $\rho = 0.04740904$
 $y_{comp} = 9.4781187E-006$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.2559188$
 $A = 0.01627594$
 $B = 0.0085861$
with $E_s = 200000.00$

Calculation of ratio l_b / d

Adequate Lap Length: $l_b / d \geq 1$

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

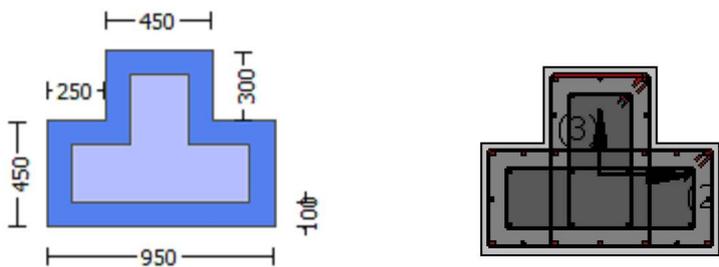
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.22443
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -2.5090294E-020
EDGE -B-
Shear Force, Vb = 2.5090294E-020
BOTH EDGES
Axial Force, F = -20792.022
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Asl,t = 0.00
-Compression: Asl,c = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio, $V_e/V_r = 1.03465$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.0610E+009$
 $Mu_{1+} = 1.9075E+009$, 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
 $Mu_{1-} = 2.0610E+009$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.0610E+009$
 $Mu_{2+} = 1.9075E+009$, 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
 $Mu_{2-} = 2.0610E+009$, 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:
 $\phi_u = 5.2259729E-005$
 $Mu = 1.9075E+009$

with full section properties:

b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.022
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01151713$

w_e (5.4c) = 0.04017143

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.48363$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.97078$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00424426$

c = confinement factor = 1.22443

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su1 = 0.4 * e_{su1,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $e_{su1,nominal} = 0.08$,

For calculation of $e_{su1,nominal}$ and $y1$, $sh1$, $ft1$, $fy1$, it is considered

characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 694.45$

with $Es_1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/lb_{min} = 1.00$

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$fy_v = 694.45$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/ld = 1.00$

$su_v = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsy_v = fs_v/1.2$, 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.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04823141$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07756398$

$v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.0838636$

and confined core properties:

$b = 890.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.40604$

$cc (5A.5, TBDY) = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05376434$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.08646184$

$v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.09348412$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y_2}$ - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

$su (4.8) = 0.13390923$

$Mu = MRc (4.15) = 1.9075E+009$

$u = su (4.1) = 5.2259729E-005$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu1-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 6.5076774E-005$$

$$\text{Mu} = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.01151713$$

$$\mu_e \text{ (5.4c)} = 0.04017143$$

$$\mu_{se} \text{ ((5.4d), TBDY)} = (\mu_{se1} * A_{ext} + \mu_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\mu_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\mu_{se2} (\geq \mu_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00424426$

$$c = \text{confinement factor} = 1.22443$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esu_{1, \text{nominal}} = 0.08$,

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{\text{jacket}} * A_{sl, \text{ten, jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 694.45$$

$$\text{with } Es_1 = (Es_{\text{jacket}} * A_{sl, \text{ten, jacket}} + Es_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su_2 = 0.4 * esu_{2, \text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esu_{2, \text{nominal}} = 0.08$,

For calculation of $esu_{2, \text{nominal}}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{\text{jacket}} * A_{sl, \text{com, jacket}} + fs_{\text{core}} * A_{sl, \text{com, core}}) / A_{sl, \text{com}} = 694.45$$

$$\text{with } Es_2 = (Es_{\text{jacket}} * A_{sl, \text{com, jacket}} + Es_{\text{core}} * A_{sl, \text{com, core}}) / A_{sl, \text{com}} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esuv_{\text{nominal}} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{\text{nominal}}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{\text{jacket}} * A_{sl, \text{mid, jacket}} + fs_{\text{mid}} * A_{sl, \text{mid, core}}) / A_{sl, \text{mid}} = 694.45$$

$$\text{with } Es_v = (Es_{\text{jacket}} * A_{sl, \text{mid, jacket}} + Es_{\text{mid}} * A_{sl, \text{mid, core}}) / A_{sl, \text{mid}} = 200000.00$$

$$1 = A_{sl, \text{ten}} / (b * d) * (fs_1 / f_c) = 0.16374619$$

$$2 = A_{sl, \text{com}} / (b * d) * (fs_2 / f_c) = 0.10182187$$

$$v = A_{sl, \text{mid}} / (b * d) * (fsv / f_c) = 0.17704537$$

and confined core properties:

$$b = 390.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 40.40604$$

$$cc (5A.5, \text{TBDY}) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl, \text{ten}} / (b * d) * (fs_1 / f_c) = 0.19731035$$

$$2 = A_{sl, \text{com}} / (b * d) * (fs_2 / f_c) = 0.12269298$$

$$v = A_{sl, \text{mid}} / (b * d) * (fsv / f_c) = 0.21333555$$

Case/Assumption: Unconfined full section - Steel rupture

satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

s_u (4.8) = 0.30448812

$\mu_u = M_{Rc}$ (4.15) = 2.0610E+009

$u = s_u$ (4.1) = 6.5076774E-005

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 5.2259729E-005$

$\mu_u = 1.9075E+009$

with full section properties:

$b = 950.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093808$

$N = 20792.022$

$f_c = 33.00$

α (5A.5, TBDY) = 0.002

Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\alpha_c = 0.01151713$

w_e (5.4c) = 0.04017143

α_{se} ((5.4d), TBDY) = $(\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\alpha_{se2} (\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.48363$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = $0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = $(fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with Es1 = $(Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = $0.4 * esu2_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = $(fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

with Es2 = $(Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = $0.4 * esuv_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv, ftv, fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04823141$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07756398$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.0838636$

and confined core properties:

$b = 890.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.40604$

$cc (5A.5, TBDY) = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05376434$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08646184$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09348412$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$su (4.8) = 0.13390923$

$Mu = MRc (4.15) = 1.9075E+009$

$u = su (4.1) = 5.2259729E-005$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 6.5076774E-005$

$Mu = 2.0610E+009$

with full section properties:

$b = 450.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00198039$

$N = 20792.022$

$f_c = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.01151713$

$w_e (5.4c) = 0.04017143$

$ase ((5.4d), TBDY) = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.53375773$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).

$$ase2 (\geq ase1) = \text{Max}(((Aconf,max2 - AnoConf2) / Aconf,max2) * (Aconf,min2 / Aconf,max2), 0) = 0.53375773$$

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 = 252164.00 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 = 111441.00 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.

$$AnoConf2 = 110709.333 \text{ is the unconfined internal core area which is equal to } bi^2/6 \text{ as defined at (A.2).}$$

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.48363$$

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.48363$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

Lstir1 (Length of stirrups along X) = 2560.00

Astir1 (stirrups area) = 78.53982

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$$

Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

$$Asec = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/d = 1.00$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 694.45$$

$$\text{with } Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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 $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$fy_v = 694.45$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lou_{min} = lb/d = 1.00$

$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

with $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.16374619$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.10182187$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.17704537$

and confined core properties:

$b = 390.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.40604$

$cc (5A.5, TBDY) = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.19731035$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.12269298$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.21333555$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$su (4.8) = 0.30448812$

$Mu = MRc (4.15) = 2.0610E+009$

$u = su (4.1) = 6.5076774E-005$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.3280E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.3280E+006$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{ColO}$

$V_{ColO} = 1.3280E+006$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot fy \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $fc'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 1534.018$

$V_u = 2.5090294E-020$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 20792.022$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 936062.473$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$
 $V_{s,j1} = 523602.964$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$
 $V_{s,c1} = 98297.73$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 1.3280E+006$
 $knl = 1$ (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: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 1534.018$
 $V_u = 2.5090294E-020$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 20792.022$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 936062.473$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837764.743$
 $V_{s,j1} = 523602.964$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

s/d = 0.16666667

Vs,j2 = 314161.779 is calculated for section flange jacket, with:

d = 360.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs,j2 is multiplied by Col,j2 = 1.00

s/d = 0.27777778

Vs,core = Vs,c1 + Vs,c2 = 98297.73

Vs,c1 = 98297.73 is calculated for section web core, with:

d = 440.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs,c1 is multiplied by Col,c1 = 1.00

s/d = 0.56818182

Vs,c2 = 0.00 is calculated for section flange core, with:

d = 200.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs,c2 is multiplied by Col,c2 = 0.00

s/d = 1.25

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 1.0304E+006

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 694.45

Existing Column

New material: Steel Strength, fs = 1.25*fsm = 694.45

#####

Max Height, Hmax = 750.00

Min Height, Hmin = 450.00

Max Width, Wmax = 950.00

Min Width, Wmin = 450.00

Eccentricity, Ecc = 250.00

Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.22443
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min > = 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.5362867E-036$
EDGE -B-
Shear Force, $V_b = -1.5362867E-036$
BOTH EDGES
Axial Force, $F = -20792.022$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1539.38$
-Compression: $As_{c,com} = 1539.38$
-Middle: $As_{mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.0549$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6949E+006$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.5424E+009$
 $Mu_{1+} = 2.5424E+009$, 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
 $Mu_{1-} = 2.5424E+009$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.5424E+009$
 $Mu_{2+} = 2.5424E+009$, 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
 $Mu_{2-} = 2.5424E+009$, 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:
 $\phi_u = 4.7487455E-005$
 $M_u = 2.5424E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.022$
 $f_c = 33.00$
 $\omega (5A.5, TBDY) = 0.002$
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01151713$

w_e (5.4c) = 0.04017143

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00424426$

c = confinement factor = 1.22443

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o / l_{ou,min} = l_b / l_d = 1.00$

$su_1 = 0.4 * esu_1_{nominal}$ ((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 $fs_1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 694.45$
 with $Es_1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{ou,min} = lb/lb_{min} = 1.00$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2 / 1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$
 with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{ou,min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv / 1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv / 1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07936942$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07936942$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.18627516$
 and confined core properties:
 $b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09471283$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09471283$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.2222852$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.2570428$
 $Mu = MRc (4.15) = 2.5424E+009$
 $u = su (4.1) = 4.7487455E-005$

 Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$\mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01151713$$

$$\phi_{we}(5.4c) = 0.04017143$$

$$\phi_{ase}((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (> \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.48363$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.48363$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.97078$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00424426$

$$c = \text{confinement factor} = 1.22443$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esu_{1, \text{nominal}} = 0.08$,

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

$$\text{with } Es_1 = (Es_{\text{jacket}} * Asl, \text{ten, jacket} + Es_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su_2 = 0.4 * esu_{2, \text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esu_{2, \text{nominal}} = 0.08$,

For calculation of $esu_{2, \text{nominal}}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{\text{jacket}} * Asl, \text{com, jacket} + fs_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

$$\text{with } Es_2 = (Es_{\text{jacket}} * Asl, \text{com, jacket} + Es_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esuv_{\text{nominal}} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{\text{nominal}}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{\text{jacket}} * Asl, \text{mid, jacket} + fs_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

$$\text{with } Es_v = (Es_{\text{jacket}} * Asl, \text{mid, jacket} + Es_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.07936942$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.07936942$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 40.40604$$

$$cc (5A.5, \text{TBDY}) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.09471283$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.09471283$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $s_u(4.8) = 0.2570428$
 $\mu = MR_c(4.15) = 2.5424E+009$
 $u = s_u(4.1) = 4.7487455E-005$

 Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

 Calculation of μ_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 4.7487455E-005$
 $\mu = 2.5424E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.022$
 $f_c = 33.00$
 $\alpha(5A.5, TBDY) = 0.002$

Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha_c, \alpha_{cc}) = 0.01151713$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha_c = 0.01151713$

$w_e(5.4c) = 0.04017143$

$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\alpha_{se2} (\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$

$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

psh2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = $0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $Min(1, 1.25 * (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = $(fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with Es1 = $(Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = $0.4 * esu2_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $Min(1, 1.25 * (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = $(fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$

with Es2 = $(Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = $0.4 * esuv_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv, ftv, fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $Min(1, 1.25 * (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_s \cdot j_{\text{jacket}} \cdot A_{s1, \text{mid, jacket}} + f_s \cdot \text{mid} \cdot A_{s1, \text{mid, core}}) / A_{s1, \text{mid}} = 694.45$
 with $E_{sv} = (E_s \cdot j_{\text{jacket}} \cdot A_{s1, \text{mid, jacket}} + E_s \cdot \text{mid} \cdot A_{s1, \text{mid, core}}) / A_{s1, \text{mid}} = 200000.00$
 $1 = A_{s1, \text{ten}} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07936942$
 $2 = A_{s1, \text{com}} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07936942$
 $v = A_{s1, \text{mid}} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.18627516$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 40.40604$
 $cc (5A.5, \text{TBDY}) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = A_{s1, \text{ten}} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09471283$
 $2 = A_{s1, \text{com}} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09471283$
 $v = A_{s1, \text{mid}} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.2222852$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$su (4.8) = 0.2570428$

$Mu = MRc (4.15) = 2.5424E+009$

$u = su (4.1) = 4.7487455E-005$

 Calculation of ratio l_b/d

 Adequate Lap Length: $l_b/d \geq 1$

 Calculation of Mu_2 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 4.7487455E-005$

$Mu = 2.5424E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.022$
 $f_c = 33.00$
 $co (5A.5, \text{TBDY}) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01151713$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.01151713$

$w_e (5.4c) = 0.04017143$

$ase ((5.4d), \text{TBDY}) = (ase1 \cdot A_{\text{ext}} + ase2 \cdot A_{\text{int}}) / A_{\text{sec}} = 0.53375773$

$ase1 = \text{Max}(((A_{\text{conf,max1}} - A_{\text{noConf1}}) / A_{\text{conf,max1}}) \cdot (A_{\text{conf,min1}} / A_{\text{conf,max1}}), 0) = 0.53375773$

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.

$A_{\text{conf,max1}} = 464100.00$ 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.

$A_{\text{conf,min1}} = 395025.00$ 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.

$A_{\text{noConf1}} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (\geq ase1) = \text{Max}(((A_{\text{conf,max2}} - A_{\text{noConf2}}) / A_{\text{conf,max2}}) \cdot (A_{\text{conf,min2}} / A_{\text{conf,max2}}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.48363$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.97078$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$

and also multiplied by the $shear_factor$ according to 15.7.1.4, with

$Shear_factor = 1.00$

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * esu_{1,nominal}$ ((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 $fs_1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 694.45$

with $Es_1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$

and also multiplied by the $shear_factor$ according to 15.7.1.4, with

$Shear_factor = 1.00$

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

$su_2 = 0.4 * esu_{2,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_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 $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$
 with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv, shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1,ft_1,fy_1 , are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07936942$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07936942$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.18627516$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40604$
 $cc (5A.5, TBDY) = 0.00424426$
 $c = \text{confinement factor} = 1.22443$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09471283$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09471283$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.2222852$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < vs,y_2$ - LHS eq.(4.5) is not satisfied

$v < vs,c$ - RHS eq.(4.5) is satisfied

$su (4.8) = 0.2570428$

$Mu = MRc (4.15) = 2.5424E+009$

$u = su (4.1) = 4.7487455E-005$

 Calculation of ratio lb/ld

 Adequate Lap Length: $lb/ld \geq 1$

 Calculation of Shear Strength $Vr = Min(Vr_1, Vr_2) = 1.6067E+006$

 Calculation of Shear Strength at edge 1, $Vr_1 = 1.6067E+006$

$Vr_1 = VCol ((10.3), ASCE 41-17) = knl \cdot VColO$

$VColO = 1.6067E+006$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $Vs = Av \cdot fy \cdot d / s$ ' is replaced by ' $Vs + f \cdot Vf$ '

where Vf is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 1.22925$

$Vu = 1.5362867E-036$

$d = 0.8 \cdot h = 760.00$
 $Nu = 20792.022$
 $Ag = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.1114E+006$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977392.20$
 $V_{s,j1} = 314161.779$ is calculated for section web jacket, with:
 $d = 360.00$
 $Av = 157079.633$
 $fy = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:
 $d = 760.00$
 $Av = 157079.633$
 $fy = 555.56$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $Av = 100530.965$
 $fy = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 134042.359$ is calculated for section flange core, with:
 $d = 600.00$
 $Av = 100530.965$
 $fy = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.6067E+006$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $knl \cdot V_{Col0}$
 $V_{Col0} = 1.6067E+006$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = Av \cdot fy \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/d = 2.00$
 $Mu = 1.22925$
 $Vu = 1.5362867E-036$
 $d = 0.8 \cdot h = 760.00$
 $Nu = 20792.022$
 $Ag = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.1114E+006$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977392.20$
 $V_{s,j1} = 314161.779$ is calculated for section web jacket, with:
 $d = 360.00$
 $Av = 157079.633$
 $fy = 555.56$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$

Vs,j2 = 663230.422 is calculated for section flange jacket, with:

d = 760.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs,j2 is multiplied by Col,j2 = 1.00

s/d = 0.13157895

Vs,core = Vs,c1 + Vs,c2 = 134042.359

Vs,c1 = 0.00 is calculated for section web core, with:

d = 200.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs,c1 is multiplied by Col,c1 = 0.00

s/d = 1.25

Vs,c2 = 134042.359 is calculated for section flange core, with:

d = 600.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs,c2 is multiplied by Col,c2 = 1.00

s/d = 0.41666667

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 1.3051E+006

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Max Height, Hmax = 750.00

Min Height, Hmin = 450.00

Max Width, Wmax = 950.00

Min Width, Wmin = 450.00

Eccentricity, Ecc = 250.00

Jacket Thickness, tj = 100.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d >= 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -72101.197$
Shear Force, $V2 = 5106.265$
Shear Force, $V3 = -68.69811$
Axial Force, $F = -21370.837$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1539.38$
-Compression: $As_{c,com} = 2475.575$
-Middle: $As_{c,mid} = 2676.637$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 1231.504$
-Compression: $As_{c,com,jacket} = 1859.823$
-Middle: $As_{c,mid,jacket} = 2060.885$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 307.8761$
-Compression: $As_{c,com,core} = 615.7522$
-Middle: $As_{c,mid,core} = 615.7522$
Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^* u = 0.044122$
 $u = y + p = 0.044122$

- Calculation of y -

 $y = (M_y * L_s / 3) / E_{eff} = 0.00165968$ ((4.29), Biskinis Phd))
 $M_y = 8.7053E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1049.537
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.8350E+014$
 $factor = 0.30$
 $A_g = 562500.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 21370.837$
 $E_c * I_g = E_c_{jacket} * I_g_{jacket} + E_c_{core} * I_g_{core} = 6.1166E+014$

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, $b = 950.00$
web width, $b_w = 450.00$
flange thickness, $t = 450.00$

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.9084537E-006$
with $f_y = 555.56$
 $d = 707.00$
 $y = 0.19954511$
 $A = 0.01002019$
 $B = 0.00468716$
with $pt = 0.00229194$
 $pc = 0.00368581$
 $pv = 0.00398517$

$N = 21370.837$
 $b = 950.00$
 $" = 0.06082037$
 $y_{comp} = 1.5661541E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19869078$
 $A = 0.0098906$
 $B = 0.00462988$
 with $E_s = 200000.00$
 CONFIRMATION: $y = 0.19954511 < t/d$

 Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

 - Calculation of p -

From table 10-8: $p = 0.04246232$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 1.03465$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.0035764$

jacket: $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00301593$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2160.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00056047$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1568.00$, 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.

$N_{UD} = 21370.837$

$A_g = 562500.00$

$f_{cE} = (f_{c_jacket} * Area_jacket + f_{c_core} * Area_core) / section_area = 33.00$

$f_{yE} = (f_{y_ext_Long_Reinf} * Area_ext_Long_Reinf + f_{y_int_Long_Reinf} * Area_int_Long_Reinf) / Area_Tot_Long_Rein =$

555.56

$f_{tE} = (f_{y_ext_Trans_Reinf} * s_1 + f_{y_int_Trans_Reinf} * s_2) / (s_1 + s_2) = 555.56$

$p_l = Area_Tot_Long_Rein / (b * d) = 0.00996292$

$b = 950.00$

$d = 707.00$

$f_{cE} = 33.00$

 End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

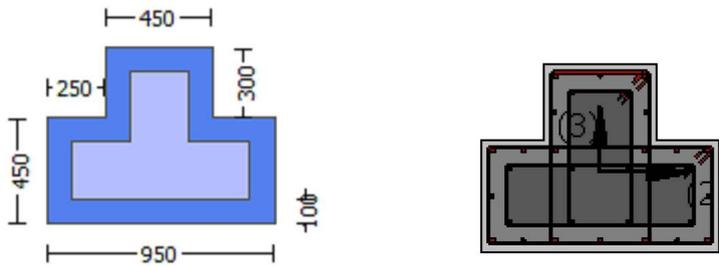
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -133381.819
Shear Force, Va = 68.69811
EDGE -B-
Bending Moment, Mb = -72101.197
Shear Force, Vb = -68.69811
BOTH EDGES
Axial Force, F = -21370.837
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Asl,t = 0.00
-Compression: Asl,c = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 1.1842E+006$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 1.1842E+006$
 $V_{CoI} = 1.1842E+006$
 $k_n = 1.00$
displacement_ductility_demand = 1.3403731E-007

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/d = 2.00$
 $M_u = 72101.197$
 $V_u = 68.69811$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 21370.837$
 $A_g = 337500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 842449.486$
where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 753982.237$
 $V_{s,j1} = 471238.898$ 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 $Col,j1 = 1.00$
 $s/d = 0.16666667$

$V_{s,j2} = 282743.339$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$$s/d = 0.27777778$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 88467.249$$

$V_{s,c1} = 88467.249$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$

$$s/d = 1.25$$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 896810.169$

$$bw = 450.00$$

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 $\theta = 2.2245867E-010$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00165968 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 8.7053E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1049.537$$

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.8350E+014$

$$factor = 0.30$$

$$A_g = 562500.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$$

$$N = 21370.837$$

$$E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 6.1166E+014$$

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, $b = 950.00$

web width, $bw = 450.00$

flange thickness, $t = 450.00$

$$y = \text{Min}(y_{ten}, y_{com})$$

$$y_{ten} = 4.9084537E-006$$

with $f_y = 555.56$

$$d = 707.00$$

$$y = 0.19954511$$

$$A = 0.01002019$$

$$B = 0.00468716$$

$$\text{with } pt = 0.00229194$$

$$pc = 0.00368581$$

$$pv = 0.00398517$$

$$N = 21370.837$$

$$b = 950.00$$

" = 0.06082037
y_comp = 1.5661541E-005
with fc = 33.00
Ec = 26999.444
y = 0.19869078
A = 0.0098906
B = 0.00462988
with Es = 200000.00
CONFIRMATION: y = 0.19954511 < t/d

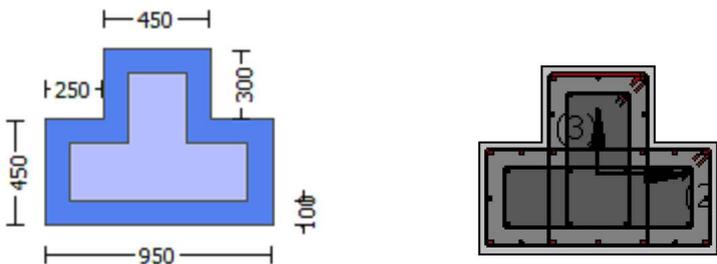
Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

End Of Calculation of Shear Capacity for element: column JTC1 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 (u)
Edge: End
Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22443

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -2.5090294E-020$

EDGE -B-

Shear Force, $V_b = 2.5090294E-020$

BOTH EDGES

Axial Force, $F = -20792.022$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1539.38$

-Compression: $A_{sl,com} = 2475.575$

-Middle: $A_{sl,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.03465$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3740E+006$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.0610E+009$

$M_{u1+} = 1.9075E+009$, 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

$M_{u1-} = 2.0610E+009$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.0610E+009$

$\mu_{2+} = 1.9075E+009$, 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

$\mu_{2-} = 2.0610E+009$, 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:

$$\mu = 5.2259729E-005$$

$$\mu = 1.9075E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141

2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398

v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636

and confined core properties:

b = 890.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

$$cc \text{ (5A.5, TBDY)} = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is not satisfied

--->
v < vs,c - RHS eq.(4.5) is satisfied

--->
su (4.8) = 0.13390923
Mu = MRc (4.15) = 1.9075E+009
u = su (4.1) = 5.2259729E-005

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.5076774E-005$$

$$Mu = 2.0610E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$fc = 33.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.01151713$
we (5.4c) = 0.04017143

$$ase \text{ ((5.4d), TBDY)} = (ase1*Aext+ase2*Aint)/Asec = 0.53375773$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1), 0) = 0.53375773$$

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 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2), 0) = 0.53375773$$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $bi2/6$ as defined at (A.2).
 $psh,min*Fywe = \text{Min}(psh,x*Fywe , psh,y*Fywe) = 2.48363$

 $psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.48363$
 $psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593$
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
 $psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047$
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

 $psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.97078$
 $psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443$
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345$
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426
c = confinement factor = 1.22443

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1,1.25*(lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1,1.25*(lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and γ_v , sh_v, ft_v, fy_v , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

$$\gamma_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.16374619$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.10182187$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.17704537$$

and confined core properties:

$$b = 390.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.19731035$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.12269298$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.21333555$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

$$s_u (4.8) = 0.30448812$$

$$M_u = M_{Rc} (4.15) = 2.0610E+009$$

$$u = s_u (4.1) = 6.5076774E-005$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of M_{u2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 5.2259729E-005$$

$$M_u = 1.9075E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01151713$$

$$\phi_{cc} (5.4c) = 0.04017143$$

$$\text{ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773}$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

Aconf,max1 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
ase2 (\geq ase1) = $\text{Max}((A_{\text{conf,max2}} - A_{\text{noconf2}})/A_{\text{conf,max2}} * (A_{\text{conf,min2}}/A_{\text{conf,max2}}), 0) = 0.53375773$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
psh,min*Fywe = $\text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.48363$

psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.48363
psh1 ((5.4d), TBDY) = $L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00301593$

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = $L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00056047$

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.97078
psh1 ((5.4d), TBDY) = $L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00357443$

Lstir1 (Length of stirrups along X) = 2560.00

Astir1 (stirrups area) = 78.53982

psh2 ((5.4d), TBDY) = $L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00070345$

Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = $0.4 * esu1_{\text{nominal}}$ ((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 = $(f_{s,jacket} * A_{s,t,jacket} + f_{s,core} * A_{s,t,core}) / A_{s,t} = 694.45$

with Es1 = $(E_{s,jacket} * A_{s,t,jacket} + E_{s,core} * A_{s,t,core}) / A_{s,t} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04823141

2 = Asl,com/(b*d)*(fs2/fc) = 0.07756398

v = Asl,mid/(b*d)*(fsv/fc) = 0.0838636

and confined core properties:

b = 890.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05376434

2 = Asl,com/(b*d)*(fs2/fc) = 0.08646184

v = Asl,mid/(b*d)*(fsv/fc) = 0.09348412

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.13390923

Mu = MRc (4.15) = 1.9075E+009

u = su (4.1) = 5.2259729E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 6.5076774E-005

Mu = 2.0610E+009

with full section properties:

b = 450.00

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (> a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16374619

2 = Asl,com/(b*d)*(fs2/fc) = 0.10182187

v = Asl,mid/(b*d)*(fsv/fc) = 0.17704537

and confined core properties:

b = 390.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.19731035

2 = Asl,com/(b*d)*(fs2/fc) = 0.12269298

v = Asl,mid/(b*d)*(fsv/fc) = 0.21333555

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.30448812

Mu = MRc (4.15) = 2.0610E+009

u = su (4.1) = 6.5076774E-005

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.3280\text{E}+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.3280\text{E}+006$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{\text{Col}0}$

$V_{\text{Col}0} = 1.3280\text{E}+006$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1534.018$

$V_u = 2.5090294\text{E}-020$

$d = 0.8 * h = 600.00$

$N_u = 20792.022$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 936062.473$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 837764.743$

$V_{s,j1} = 523602.964$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.27777778$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 98297.73$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 0.00$

$s/d = 1.25$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 1.0304\text{E}+006$

$b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.3280\text{E}+006$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{\text{Col}0}$

$V_{\text{Col}0} = 1.3280\text{E}+006$

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1534.018$

$V_u = 2.5090294E-020$

$d = 0.8 \cdot h = 600.00$

$N_u = 20792.022$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 936062.473$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 837764.743$

$V_{s,j1} = 523602.964$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 314161.779$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.27777778$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 98297.73$

$V_{s,c1} = 98297.73$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 0.00$

$s/d = 1.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 1.0304E+006$

$b_w = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

```

Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
#####
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.22443
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lu,min>=1)
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force, Va = 1.5362867E-036
EDGE -B-
Shear Force, Vb = -1.5362867E-036
BOTH EDGES
Axial Force, F = -20792.022
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension: Asl,t = 0.00
  -Compression: Asl,c = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension: Asl,ten = 1539.38
  -Compression: Asl,com = 1539.38
  -Middle: Asl,mid = 3612.832
-----
-----

Calculation of Shear Capacity ratio , Ve/Vr = 1.0549
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.6949E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5424E+009
  Mu1+ = 2.5424E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
  which is defined for the static loading combination
  Mu1- = 2.5424E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment
  direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5424E+009
  Mu2+ = 2.5424E+009, 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

$\mu_{2-} = 2.5424E+009$, 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:

$$\mu = 4.7487455E-005$$

$$\mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e \text{ (5.4c)} = 0.04017143$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.48363$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.97078$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00424426

c = confinement factor = 1.22443

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fsjacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443
1 = $Asl,ten/(b*d)*(fs1/fc) = 0.09471283$
2 = $Asl,com/(b*d)*(fs2/fc) = 0.09471283$
v = $Asl,mid/(b*d)*(fsv/fc) = 0.2222852$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is not satisfied

--->
v < vs,c - RHS eq.(4.5) is satisfied

--->
su (4.8) = 0.2570428
Mu = MRc (4.15) = 2.5424E+009
u = su (4.1) = 4.7487455E-005

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 4.7487455E-005
Mu = 2.5424E+009

with full section properties:

b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.022

fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01151713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01151713

we (5.4c) = 0.04017143
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773

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 = 464100.00 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 = 395025.00 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 = 173066.667 is the unconfined external core area which is equal to bi²/6 as defined at (A.2).

ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to bi²/6 as defined at (A.2).

$$psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 2.48363$$

$$psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.48363$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.97078$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2560.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1968.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou_{min} = lb/ld = 1.00$$

$$su1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 694.45$$

$$\text{with } Es1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou_{min} = lb/lb_{min} = 1.00$$

$$su2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu2_{nominal} = 0.08$,

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 694.45$$

$$\text{with } Es2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$su_v = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou_{min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1$, $sh1,ft1,fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 694.45$$

$$\text{with } Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.07936942$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.07936942$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.40604$$

$$cc (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.09471283$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.09471283$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$ - LHS eq.(4.5) is not satisfied

--->

$v < vs,c$ - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.2570428$$

$$Mu = MRc (4.15) = 2.5424E+009$$

$$u = su (4.1) = 4.7487455E-005$$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of $Mu2+$

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$Mu = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01151713$$

$$we (5.4c) = 0.04017143$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.53375773$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1) / Aconf,max1) * (Aconf,min1 / Aconf,max1), 0) = 0.53375773$$

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.

$Aconf,max1 = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase_2 (>=ase_1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.48363$

 $psh_x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.48363$

psh_1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

psh_2 (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

 $psh_y * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.97078$

psh_1 ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

psh_2 ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424426$

$c = \text{confinement factor} = 1.22443$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_0/l_{ou,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * esu_{1,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_1 = fs_1/1.2$, 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 $fs_1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$

with $Es_1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_{b,min} = 1.00$$

$$s_u = 0.4 \cdot e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{sjacket} \cdot A_{sl,com,jacket} + f_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 694.45$$

$$\text{with } E_{s2} = (E_{sjacket} \cdot A_{sl,com,jacket} + E_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 \cdot e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 694.45$$

$$\text{with } E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07936942$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07936942$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.18627516$$

and confined core properties:

$$b = 390.00$$

$$d = 877.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.40604$$

$$c_c (5A.5, TBDY) = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09471283$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09471283$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.2222852$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

$$s_u (4.8) = 0.2570428$$

$$\mu_u = M_{Rc} (4.15) = 2.5424E+009$$

$$u = s_u (4.1) = 4.7487455E-005$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_u -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 4.7487455E-005$$

$$\mu_u = 2.5424E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.022$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01151713$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01151713$$

$$w_e (5.4c) = 0.04017143$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (> a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.48363$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.48363$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.97078$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along } X) = 2560.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along } X) = 1968.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00424426$$

$$c = \text{confinement factor} = 1.22443$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07936942

2 = Asl,com/(b*d)*(fs2/fc) = 0.07936942

v = Asl,mid/(b*d)*(fsv/fc) = 0.18627516

and confined core properties:

b = 390.00

d = 877.00

d' = 13.00

fcc (5A.2, TBDY) = 40.40604

cc (5A.5, TBDY) = 0.00424426

c = confinement factor = 1.22443

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09471283

2 = Asl,com/(b*d)*(fs2/fc) = 0.09471283

v = Asl,mid/(b*d)*(fsv/fc) = 0.2222852

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.2570428

Mu = MRc (4.15) = 2.5424E+009

u = su (4.1) = 4.7487455E-005

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.6067E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.6067E+006$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 1.6067E+006$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.22925$

$V_u = 1.5362867E-036$

$d = 0.8 * h = 760.00$

$N_u = 20792.022$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.1114E+006$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977392.20$

$V_{s,j1} = 314161.779$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j1}$ is multiplied by $Col_{j1} = 1.00$

$s/d = 0.27777778$

$V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j2}$ is multiplied by $Col_{j2} = 1.00$

$s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 134042.359$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col_{c1} = 0.00$

$s/d = 1.25$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col_{c2} = 1.00$

$s/d = 0.41666667$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$

$bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.6067E+006$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 1.6067E+006$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.22925$

$V_u = 1.5362867E-036$

$d = 0.8 \cdot h = 760.00$

$N_u = 20792.022$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 1.1114E+006$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 977392.20$

$V_{s,j1} = 314161.779$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.27777778$

$V_{s,j2} = 663230.422$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.13157895$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 134042.359$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 0.00$

$s/d = 1.25$

$V_{s,c2} = 134042.359$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 1.00$

$s/d = 0.41666667$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 1.3051E+006$

$b_w = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d >= 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 135519.787$

Shear Force, $V_2 = 5106.265$

Shear Force, $V_3 = -68.69811$

Axial Force, $F = -21370.837$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1539.38$

-Compression: $A_{st,com} = 1539.38$

-Middle: $A_{st,mid} = 3612.832$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten,jacket} = 1231.504$

-Compression: $A_{st,com,jacket} = 1231.504$

-Middle: $A_{st,mid,jacket} = 2689.203$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten,core} = 307.8761$

-Compression: $A_{st,com,core} = 307.8761$

-Middle: $A_{st,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 16.57143$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04539179$

$u = y + p = 0.04539179$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00042953$ ((4.29), Biskinis Phd))

$M_y = 1.1979E+009$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.7887E+014$

factor = 0.30

$A_g = 562500.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 21370.837$

$$E_c I_g = E_c I_{g_jacket} + E_c I_{g_core} = 9.2958E+014$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$$y = \text{Min}(y_{ten}, y_{com})$$

$$y_{ten} = 4.1202810E-006$$

with $f_y = 555.56$

$$d = 907.00$$

$$y = 0.25669535$$

$$A = 0.01648918$$

$$B = 0.00868035$$

with $p_t = 0.0037716$

$$p_c = 0.0037716$$

$$p_v = 0.00885172$$

$$N = 21370.837$$

$$b = 450.00$$

$$" = 0.04740904$$

$$y_{comp} = 9.4781187E-006$$

with $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.2559188$$

$$A = 0.01627594$$

$$B = 0.0085861$$

with $E_s = 200000.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.04496226$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 1.0549$

$d = d_{external} = 907.00$

$s = s_{external} = 0.00$

- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00427788$

jacket: $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00357443$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2560.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00070345$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1968.00$, 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.

$N_{UD} = 21370.837$

$A_g = 562500.00$

$f_{cE} = (f_{c_jacket} * Area_{jacket} + f_{c_core} * Area_{core}) / section_area = 33.00$

$f_{yE} = (f_{y_ext_Long_Reinf} * Area_{ext_Long_Reinf} + f_{y_int_Long_Reinf} * Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} =$

555.56

$f_{yE} = (f_{y_ext_Trans_Reinf} * s_1 + f_{y_int_Trans_Reinf} * s_2) / (s_1 + s_2) = 555.56$

$p_l = Area_{Tot_Long_Rein} / (b * d) = 0.01639493$

$b = 450.00$

$d = 907.00$

$f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
