

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

beam B1, Floor 1

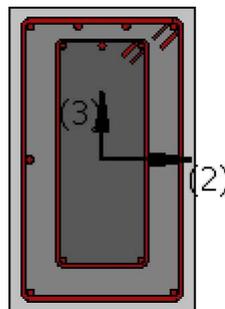
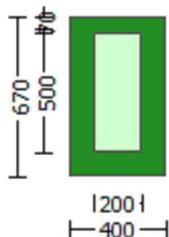
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 670.00$
External Width, $W = 400.00$
Internal Height, $H = 500.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.9313521E-011$
Shear Force, $V_a = -8.3688847E-015$
EDGE -B-
Bending Moment, $M_b = -5.9825082E-012$
Shear Force, $V_b = 8.3688847E-015$
BOTH EDGES
Axial Force, $F = -6277.313$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 911.0619$
-Compression: $A_{sc,com} = 911.0619$
-Middle: $A_{st,mid} = 556.0619$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 15.20$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 327136.349$
 $V_n ((22.5.1.1), ACI 318-14) = 327136.349$

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 159584.741$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 21.64179$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 670.00$
 $d = 320.00$
 $V_u \cdot d / M_u < 1 = 0.00$
 $M_u = 1.9313521E-011$
 $V_u = 8.3688847E-015$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 167551.608$
 $V_{s1} = 167551.608$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 0.00 is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 300.00$

Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

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

From (11-11), ACI 440: $V_s + V_f \leq 662579.716$

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 2

beam B1, Floor 1

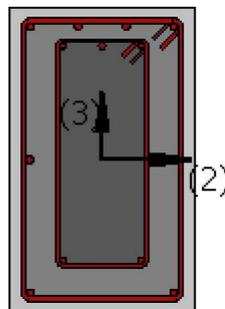
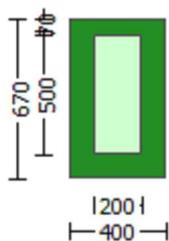
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

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Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
#####
External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03245
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lu,min>=1)
No FRP Wrapping
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Stepwise Properties
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At local axis: 3
EDGE -A-
Shear Force, Va = 9840.633
EDGE -B-
Shear Force, Vb = 9840.633
BOTH EDGES
Axial Force, F = -2285.867
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 709.9999
-Compression: Aslc = 1668.186
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 709.9999
-Compression: Asl,com = 1266.062
-Middle: Asl,mid = 402.1239
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Calculation of Shear Capacity ratio , Ve/Vr = 0.89177444
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln ± wu*ln/2 = 477716.403
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.0181E+008
Mu1+ = 4.0754E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
Mu1- = 7.0181E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.0181E+008
Mu2+ = 4.0754E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
Mu2- = 7.0181E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
and
± wu*ln = (|V1| + |V2|)/2
with

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V1 = 9840.633, is the shear force acting at edge 1 for the the static loading combination
V2 = 9840.633, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu1+

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

$$\mu = 5.5992766E-005$$

$$Mu = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00646173$$

$$w_e \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$$fy_1 = 634.2183$$

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 = 634.2183

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

y2 = 0.0025

sh2 = 0.008

ft2 = 772.5393

fy2 = 643.7827

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 = 643.7827

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

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

lo/lou,min = lb/lb,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 = 694.4444

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0544071

2 = Asl,com/(b*d)*(fs2/fc) = 0.09848107

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06722486

2 = Asl,com/(b*d)*(fs2/fc) = 0.1216822

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

--->

su (4.9) = 0.08851292

Mu = MRc (4.14) = 4.0754E+008

u = su (4.1) = 5.5992766E-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:

$$\mu = 5.9114336E-005$$

$$\mu_1 = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_c: \mu_c^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00646173$$

$$\mu_{we} \text{ (5.4c)} = 0.00548239$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.14776895$$

$$\mu_{ase1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 1.22434$$

$$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 2.16538$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 1.22434$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 772.5393$$

$$fy1 = 643.7827$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 643.7827$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 761.0619$$

$$fy2 = 634.2183$$

$$su2 = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 634.2183$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06722486$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983$$

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

--->

$$s_u(4.8) = 0.13664457$$

$$M_u = M_{Rc}(4.15) = 7.0181E+008$$

$$u = s_u(4.1) = 5.9114336E-005$$

Calculation of ratio l_b/d

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

Calculation of $M_u/2+$

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

$$u = 5.5992766E-005$$

$$M_u = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00646173$$

$$\phi_{we}(5.4c) = 0.00548239$$

$$\phi_{ase}((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.14776895$$

$$\phi_{ase1} = 0.14776895$$

$$b_{o1} = 340.00$$

$$h_{o1} = 610.00$$

$$b_{i21} = 975400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.14776895$$

$$b_{o2} = 192.00$$

$$h_{o2} = 492.00$$

$$b_{i22} = 557856.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 1.22434$$

 $\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.16538$

$$\phi_{ps1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$\phi_{ps2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

 $\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 1.22434$

$$\phi_{ps1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$\phi_{ps2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

 $A_{sec} = 268000.00$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00232446$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$$fy_1 = 634.2183$$

$$su_1 = 0.032$$

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.

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 634.2183$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 772.5393$$

$$fy_2 = 643.7827$$

$$su_2 = 0.032$$

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.

$$\text{with } fs_2 = (fs_{\text{jacket}} * Asl, \text{com, jacket} + fs_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 643.7827$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

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

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

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

considering characteristic value $fsy_v = fsv/1.2$, 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.

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.0544071$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.09848107$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 34.07072$$

$$cc (5A.5, \text{TBDY}) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.06722486$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.1216822$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.04168983$$

Case/Assumption: Unconfined full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.08851292$$

$$M_u = M_{Rc}(4.14) = 4.0754E+008$$

$$u = s_u(4.1) = 5.5992766E-005$$

Calculation of ratio l_b/l_d

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

Calculation of μ_2 -

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

$$u = 5.9114336E-005$$

$$M_u = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00646173$$

$$\mu_{cc}(5.4c) = 0.00548239$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 610.00$$

$$b_{i2,1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 492.00$$

$$b_{i2,2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.22434$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.16538$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 1.22434$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 772.5393
fy1 = 643.7827
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 = 643.7827

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

y2 = 0.0025
sh2 = 0.008
ft2 = 761.0619
fy2 = 634.2183
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 = 634.2183

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

yv = 0.0025
shv = 0.008
ftv = 833.3333
fyv = 694.4444
suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107

2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822

$$2 = A_{sl,com}/(b*d)^*(f_s2/f_c) = 0.06722486$$

$$v = A_{sl,mid}/(b*d)^*(f_{sv}/f_c) = 0.04168983$$

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) = 0.13664457

$$\mu_u = M_{Rc} \text{ (4.15)} = 7.0181E+008$$

$$u = s_u \text{ (4.1)} = 5.9114336E-005$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 535691.969$

Calculation of Shear Strength at edge 1, $V_{r1} = 535691.969$

$$V_{r1} = V_n \text{ ((22.5.1.1), ACI 318-14)}$$

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f*V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} * \text{Area}_{jacket} + f'_{c_core} * \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$p_w = A_s / (b_w * d) = 0.00331157$$

$$A_s \text{ (tension reinf.)} = 709.9999$$

$$b_w = 400.00$$

$$d = 536.00$$

$$V_u * d / \mu_u < 1 = 1.00$$

$$\mu_u = 1.1086E+006$$

$$V_u = 9840.633$$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$

$V_{s1} = 311832.16$ is calculated for jacket, with:

$$d = 536.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 150.00$$

V_{s1} has been multiplied by 1 ($s \leq d/2$, according to ASCE 41-17,10.3.4)

$V_{s2} = 29786.953$ is calculated for jacket, with:

$$d_2 = 400.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 300.00$$

V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.50$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 755657.47$$

Calculation of Shear Strength at edge 2, $V_{r2} = 535691.969$

$$V_{r2} = V_n \text{ ((22.5.1.1), ACI 318-14)}$$

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f*V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} * \text{Area}_{jacket} + f'_{c_core} * \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$pw = As/(bw*d) = 0.00331157$

As (tension reinf.) = 709.9999

$bw = 400.00$

$d = 536.00$

$Vu*d/Mu < 1 = 1.00$

$Mu = 1.1086E+006$

$Vu = 9840.633$

From (11.5.4.8), ACI 318-14: $Vs1 + Vs2 = 341619.112$

$Vs1 = 311832.16$ is calculated for jacket, with:

$d = 536.00$

$Av = 157079.633$

$fy = 555.5556$

$s = 150.00$

$Vs1$ has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$Vs2 = 29786.953$ is calculated for jacket, with:

$d = 400.00$

$Av = 100530.965$

$fy = 444.4444$

$s = 300.00$

$Vs2$ has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

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

From (11-11), ACI 440: $Vs + Vf <= 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $fs = fsm = 555.5556$

Concrete Elasticity, $Ec = 26999.444$

Steel Elasticity, $Es = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $fc = fcm = 20.00$

Existing material of Primary Member: Steel Strength, $fs = fsm = 444.4444$

Concrete Elasticity, $Ec = 21019.039$

Steel Elasticity, $Es = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength, $fs = 1.25*fsm = 694.4444$

Existing Column

Existing material: Steel Strength, $fs = 1.25*fsm = 555.5556$

#####

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03245

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

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

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.2127266E-014$
EDGE -B-
Shear Force, $V_b = -1.2127266E-014$
BOTH EDGES
Axial Force, $F = -2285.867$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 709.9999$
-Compression: $A_{sl,c} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 911.0619$
-Compression: $A_{sl,com} = 911.0619$
-Middle: $A_{sl,mid} = 556.0619$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.52117341$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 191881.096$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 2.8782E+008$
 $Mu_{1+} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $Mu_{1-} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 2.8782E+008$
 $Mu_{2+} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $Mu_{2-} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 1.2127266E-014$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = -1.2127266E-014$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 0.00010364$
 $M_u = 2.8782E+008$

with full section properties:

$b = 670.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.0002896$
 $N = 2285.867$

$f_c = 33.00$

ϕ_o (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_o) = 0.00646173$

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

From (5.4b), TBDY: $\phi_u = 0.00646173$

we (5.4c) = 0.00548239
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14776895
ase1 = 0.14776895
bo_1 = 340.00
ho_1 = 610.00
bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
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 $es_{2,nominal}$ 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 $fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 647.5096$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.194$

$fy_v = 655.995$

$suv = 0.032$

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 $fs_v = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 655.995$

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

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07473725$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07473725$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.0896195$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0896195$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su (4.9) = 0.13515888$

$Mu = MRc (4.14) = 2.8782E+008$

$u = su (4.1) = 0.00010364$

Calculation of ratio lb/ld

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

Calculation of Mu_1 -

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

$u = 0.00010364$

$Mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$fc = 33.00$

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

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$

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

From (5.4b), TBDY: $c_u = 0.00646173$

w_e (5.4c) = 0.00548239

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$

$a_{se1} = 0.14776895$

$b_{o_1} = 340.00$

$h_{o_1} = 610.00$

$b_{i2_1} = 975400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$

$b_{o_2} = 192.00$

$h_{o_2} = 492.00$

$b_{i2_2} = 557856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$

 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$

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

No stirups, $n_{s_1} = 2.00$

$h_1 = 670.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$

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

No stirups, $n_{s_2} = 2.00$

$h_2 = 500.00$

 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$

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

No stirups, $n_{s_1} = 2.00$

$h_1 = 400.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$

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

No stirups, $n_{s_2} = 2.00$

$h_2 = 200.00$

 $A_{sec} = 268000.00$

$s_1 = 150.00$

$s_2 = 300.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 777.0115$

$fy_1 = 647.5096$

$su_1 = 0.032$

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

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

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

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

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

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

with $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 647.5096$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 777.0115$

$fy_2 = 647.5096$

$su_2 = 0.032$

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

$$l_0/l_{0u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,

For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s1,com,jacket} + f_{s,core} * A_{s1,com,core}) / A_{s1,com} = 647.5096$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.194$$

$$fy_v = 655.995$$

$$s_{uv} = 0.032$$

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

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

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

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

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

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

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

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s1,mid,jacket} + f_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 655.995$$

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

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.07473725$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.07473725$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.07072$$

$$c_c (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.0896195$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.0896195$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.13515888$$

$$\mu_u = M_{Rc} (4.14) = 2.8782E+008$$

$$u = s_u (4.1) = 0.00010364$$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2+}

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

$$u = 0.00010364$$

$$\mu_u = 2.8782E+008$$

with full section properties:

$$b = 670.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0002896$$

$$N = 2285.867$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00646173$$

$$we (5.4c) = 0.00548239$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$$

$$ase1 = 0.14776895$$

$$bo_1 = 340.00$$

$$ho_1 = 610.00$$

$$bi2_1 = 975400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.14776895$$

$$bo_2 = 192.00$$

$$ho_2 = 492.00$$

$$bi2_2 = 557856.00$$

$$psh, \min * Fy_{we} = \text{Min}(psh, x * Fy_{we}, psh, y * Fy_{we}) = 1.22434$$

$$psh, x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.16538$$

$$ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00261799$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 670.00$$

$$ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00062519$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 500.00$$

$$psh, y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 1.22434$$

$$ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00156298$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00025008$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s1 = 150.00$$

$$s2 = 300.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_c = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } cc = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 777.0115$$

$$fy1 = 647.5096$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs, \text{jacket} * A_{sl, \text{ten, jacket}} + fs, \text{core} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 647.5096$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 777.0115$$

$$fy2 = 647.5096$$

$$su2 = 0.032$$

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 = 647.5096

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

yv = 0.0025

shv = 0.008

ftv = 787.194

fyv = 655.995

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 = 655.995

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07473725

2 = Asl,com/(b*d)*(fs2/fc) = 0.07473725

v = Asl,mid/(b*d)*(fsv/fc) = 0.04621327

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0896195

2 = Asl,com/(b*d)*(fs2/fc) = 0.0896195

v = Asl,mid/(b*d)*(fsv/fc) = 0.05541561

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 0.00010364

Mu = 2.8782E+008

with full section properties:

b = 670.00

$d = 357.00$
 $d' = 43.00$
 $v = 0.0002896$
 $N = 2285.867$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$
 $we (5.4c) = 0.00548239$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$
 $ase1 = 0.14776895$
 $bo_1 = 340.00$
 $ho_1 = 610.00$
 $bi2_1 = 975400.00$
 $ase2 = Max(ase1, ase2) = 0.14776895$
 $bo_2 = 192.00$
 $ho_2 = 492.00$
 $bi2_2 = 557856.00$
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.22434$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00261799$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 670.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00062519$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 500.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00156298$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00025008$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 268000.00$
 $s1 = 150.00$
 $s2 = 300.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00232446$
 $c = confinement\ factor = 1.03245$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 777.0115$
 $fy1 = 647.5096$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/d = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 647.5096$
 with $Es1 = (Es, jacket * A_{sl, ten, jacket} + Es, core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$

$$ft2 = 777.0115$$

$$fy2 = 647.5096$$

$$su2 = 0.032$$

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

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

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

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.

$$\text{with } fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 647.5096$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.194$$

$$fyv = 655.995$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 655.995$$

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

$$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.07473725$$

$$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.07473725$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.0896195$$

$$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.0896195$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

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

---->

$$su (4.9) = 0.13515888$$

$$Mu = MRc (4.14) = 2.8782E+008$$

$$u = su (4.1) = 0.00010364$$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 368171.311$

Calculation of Shear Strength at edge 1, $Vr1 = 368171.311$

$$Vr1 = Vn ((22.5.1.1), ACI 318-14)$$

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'

where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 182002.857$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 28.14925$, but $f_c^{0.5} <= 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 670.00$
 $d = 320.00$
 $V_u \cdot d / \mu < 1 = 0.00$
 $\mu = 2.3879272E-011$
 $V_u = 1.2127266E-014$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 186168.454$
 $V_{s1} = 186168.454$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 0.00$ is calculated for jacket, with:
 $d_2 = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 300.00$
 V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f <= 755657.47$

Calculation of Shear Strength at edge 2, $V_{r2} = 368171.311$
 $V_{r2} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 182002.857$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 28.14925$, but $f_c^{0.5} <= 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 670.00$
 $d = 320.00$
 $V_u \cdot d / \mu < 1 = 0.00$
 $\mu = 1.2499023E-011$
 $V_u = 1.2127266E-014$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 186168.454$
 $V_{s1} = 186168.454$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 0.00$ is calculated for jacket, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 300.00$
 V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f <= 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 4.3370E+006$

Shear Force, $V_2 = -8.3688847E-015$

Shear Force, $V_3 = 5172.783$

Axial Force, $F = -6277.313$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 709.9999$

-Compression: $A_{sc} = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 709.9999$

-Compression: $A_{sl,com} = 1266.062$

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

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten,jacket} = 402.1239$

-Compression: $A_{sl,com,jacket} = 804.2477$

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com,core} = 461.8141$

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

Mean Diameter of Tension Reinforcement, $DbL = 15.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \gamma \cdot u = 0.01092632$

$u = \gamma \cdot u + p = 0.01092632$

- Calculation of ρ_y -

$$y = (M_y * L_s / 3) / E_{eff} = 0.00092632 \text{ ((4.29), Biskinis Phd)}$$
$$M_y = 2.5663E+008$$
$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 838.4351$$
$$\text{From table 10.5, ASCE 41-17: } E_{eff} = 0.3 * E_c * I_g = 7.7426E+013$$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to Annex 7 -

$$y = \text{Min}(y_{ten}, y_{com})$$
$$y_{ten} = 5.0856178E-006$$
$$\text{with } f_y = 555.5556$$
$$d = 627.00$$
$$y = 0.18525141$$
$$A = 0.00953057$$
$$B = 0.00408197$$
$$\text{with } p_t = 0.00283094$$
$$p_c = 0.00504809$$
$$p_v = 0.00160336$$
$$N = 6277.313$$
$$b = 400.00$$
$$\rho = 0.06858054$$
$$y_{comp} = 1.9026758E-005$$
$$\text{with } f_c = 28.14925$$
$$E_c = 26999.444$$
$$y = 0.18441629$$
$$A = 0.00942552$$
$$B = 0.0040338$$
$$\text{with } E_s = 200000.00$$

Calculation of ratio l_b/d

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

- Calculation of ρ_p -

From table 10-7: $\rho_p = 0.01$

with:

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.89177444$

- Transverse Reinforcement: C

- Stirrup Spacing $\leq d/3$

- Low ductility demand, $\rho_y / \rho < 2$ (table 10-6, ASCE 41-17)

$\rho = 5.2570730E-005$

- Stirrup Spacing $\leq d/2$

$d = d_{external} = 627.00$

$s = s_{external} = 150.00$

- Strength provided by hoops $V_s < 3/4 * \text{design Shear}$

$V_s = 371406.065$, already given in calculation of shear control ratio

design Shear = 5172.783

- ($\rho - \rho'$)/ $\rho_{bal} = -0.26283917$

$\rho = A_{st} / (b_w * d) = 0.00283094$

Tension Reinf Area: $A_{st} = 709.9999$

$\rho' = A_{sc} / (b_w * d) = 0.00665146$

Compression Reinf Area: $A_{sc} = 1668.186$

From (B-1), ACI 318-11: $\rho_{bal} = 0.01453557$

$f_c = (f_{c_jacket} * \text{Area}_{jacket} + f_{c_core} * \text{Area}_{core}) / \text{section_area} = 28.14925$

$f_y = f_{y_jacket_bars} = 555.5556$

From 10.2.7.3, ACI 318-11: $\rho_1 = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000 / (87000 + f_y) = c_b/d_t = 0.003 / (0.003 + \rho_y) = 0.51923077$

$$y = 0.00277778$$

- $V/(bw*d*fc^{0.5}) = 0.04681516$, NOTE: units in lb & in

$$bw = 400.00$$

End Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

beam B1, Floor 1

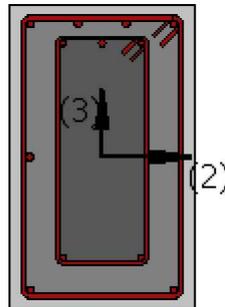
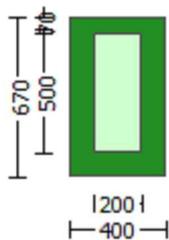
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 670.00$
External Width, $W = 400.00$
Internal Height, $H = 500.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = 4.3370E+006$
Shear Force, $V_a = 5172.783$
EDGE -B-
Bending Moment, $M_b = 9.6669E+006$
Shear Force, $V_b = 14508.483$
BOTH EDGES
Axial Force, $F = -6277.313$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 709.9999$
-Compression: $A_{st,com} = 1266.062$
-Middle: $A_{st,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 15.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 474758.126$
 V_n ((22.5.1.1), ACI 318-14) = 474758.126

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f_v V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 167300.925$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} * Area_jacket + f'_{c_core} * Area_core) / Area_section = 21.64179$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w * d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u * d / M_u < 1 = 0.63928624$
 $M_u = 4.3370E+006$
 $V_u = 5172.783$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 307457.201$
 $V_{s1} = 280648.944$ is calculated for jacket, with:
 $d = 536.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 26808.257$ is calculated for core, with:
 $d = 400.00$
 $A_v = 100530.965$

$$f_y = 400.00$$

$$s = 300.00$$

V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.50$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 662579.716$$

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 4

beam B1, Floor 1

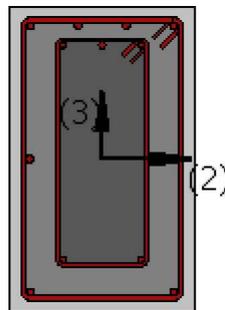
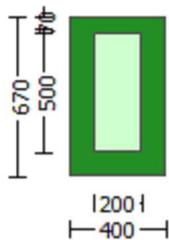
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 555.5556$

External Height, $H = 670.00$
External Width, $W = 400.00$
Internal Height, $H = 500.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.03245
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou, min} >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 9840.633$
EDGE -B-
Shear Force, $V_b = 9840.633$
BOTH EDGES
Axial Force, $F = -2285.867$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st, ten} = 709.9999$
-Compression: $A_{sc, com} = 1266.062$
-Middle: $A_{sc, mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.89177444$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u * l_n / 2 = 477716.403$
with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 7.0181E+008$
 $M_{u1+} = 4.0754E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 7.0181E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 7.0181E+008$
 $M_{u2+} = 4.0754E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $M_{u2-} = 7.0181E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
and
 $\pm w_u * l_n = (|V1| + |V2|)/2$
with
 $V1 = 9840.633$, is the shear force acting at edge 1 for the the static loading combination
 $V2 = 9840.633$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu1+

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

$$u = 5.5992766E-005$$

$$\text{Mu} = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00646173$$

$$w_e \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$$fy_1 = 634.2183$$

$$su_1 = 0.032$$

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

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 634.2183

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

y2 = 0.0025

sh2 = 0.008

ft2 = 772.5393

fy2 = 643.7827

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 = 643.7827

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0544071

2 = Asl,com/(b*d)*(fs2/fc) = 0.09848107

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06722486

2 = Asl,com/(b*d)*(fs2/fc) = 0.1216822

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.08851292

Mu = MRc (4.14) = 4.0754E+008

u = su (4.1) = 5.5992766E-005

Calculation of ratio lb/d

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

Calculation of μ_1 -

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

$$\mu = 5.9114336E-005$$

$$\mu_1 = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_1: \mu_1^* = \text{shear_factor} * \text{Max}(\mu_1, \mu_2) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu_1 = 0.00646173$$

$$\mu_2 \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy_1 = 643.7827$$

su1 = 0.032

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

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

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 643.7827

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

y2 = 0.0025

sh2 = 0.008

ft2 = 761.0619

fy2 = 634.2183

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 = 634.2183

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

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

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

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107

2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822

2 = Asl,com/(b*d)*(fs2/fc) = 0.06722486

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

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) = 0.13664457

Mu = MRc (4.15) = 7.0181E+008

$$u = s_u(4.1) = 5.9114336E-005$$

Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$$u = 5.5992766E-005$$

$$\mu = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00646173$$

$$\mu_{cc}(5.4c) = 0.00548239$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_c = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00232446$$

$c = \text{confinement factor} = 1.03245$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 761.0619$
 $fy1 = 634.2183$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 634.2183$
 with $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 772.5393$
 $fy2 = 643.7827$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/lb,min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), \text{TBDY}) = 0.032$
 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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 643.7827$
 with $Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.3333$
 $fyv = 694.4444$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 694.4444$
 with $Esv = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.0544071$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.09848107$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.03374084$
 and confined core properties:
 $b = 340.00$
 $d = 597.00$
 $d' = 13.00$
 $fcc (5A.2, \text{TBDY}) = 34.07072$
 $cc (5A.5, \text{TBDY}) = 0.00232446$
 $c = \text{confinement factor} = 1.03245$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.06722486$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.1216822$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04168983$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied

--->

$$\begin{aligned}su(4.9) &= 0.08851292 \\ \mu &= MRC(4.14) = 4.0754E+008 \\ u &= su(4.1) = 5.5992766E-005\end{aligned}$$

Calculation of ratio lb/d

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

Calculation of μ_2 -

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

$$\begin{aligned}u &= 5.9114336E-005 \\ \mu &= 7.0181E+008\end{aligned}$$

with full section properties:

$$\begin{aligned}b &= 400.00 \\ d &= 627.00 \\ d' &= 43.00 \\ v &= 0.00027619 \\ N &= 2285.867 \\ f_c &= 33.00 \\ c_o(5A.5, TBDY) &= 0.002 \\ \text{Final value of } c_u: c_u^* &= \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173 \\ \text{The Shear_factor is considered equal to 1 (pure moment strength)} \\ \text{From (5.4b), TBDY: } c_u &= 0.00646173 \\ w_e(5.4c) &= 0.00548239 \\ a_{se}((5.4d), TBDY) &= (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895 \\ a_{se1} &= 0.14776895 \\ b_{o1} &= 340.00 \\ h_{o1} &= 610.00 \\ b_{i21} &= 975400.00 \\ a_{se2} = \text{Max}(a_{se1}, a_{se2}) &= 0.14776895 \\ b_{o2} &= 192.00 \\ h_{o2} &= 492.00 \\ b_{i22} &= 557856.00 \\ p_{sh, \min} * F_{ywe} &= \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434\end{aligned}$$

$$\begin{aligned}p_{sh, x} * F_{ywe} &= p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.16538 \\ p_{s1}(\text{external}) &= (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799 \\ A_{sh1} &= A_{stir, 1} * n_{s, 1} = 157.0796 \\ \text{No stirups, } n_{s, 1} &= 2.00 \\ h_1 &= 670.00 \\ p_{s2}(\text{internal}) &= (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519 \\ A_{sh2} &= A_{stir, 2} * n_{s, 2} = 100.531 \\ \text{No stirups, } n_{s, 2} &= 2.00 \\ h_2 &= 500.00\end{aligned}$$

$$\begin{aligned}p_{sh, y} * F_{ywe} &= p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 1.22434 \\ p_{s1}(\text{external}) &= (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298 \\ A_{sh1} &= A_{stir, 1} * n_{s, 1} = 157.0796 \\ \text{No stirups, } n_{s, 1} &= 2.00 \\ h_1 &= 400.00 \\ p_{s2}(\text{internal}) &= (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008 \\ A_{sh2} &= A_{stir, 2} * n_{s, 2} = 100.531 \\ \text{No stirups, } n_{s, 2} &= 2.00 \\ h_2 &= 200.00\end{aligned}$$

$$\begin{aligned}A_{sec} &= 268000.00 \\ s_1 &= 150.00 \\ s_2 &= 300.00 \\ f_{ywe1} &= 694.4444\end{aligned}$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

From (5.A.5), TBDY, TBDY: $cc = 0.00232446$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy_1 = 643.7827$$

$$su_1 = 0.032$$

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.

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 643.7827$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 761.0619$$

$$fy_2 = 634.2183$$

$$su_2 = 0.032$$

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.

$$\text{with } fs_2 = (fs_{\text{jacket}} * Asl, \text{com, jacket} + fs_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 634.2183$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.09848107$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.0544071$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 34.07072$$

$$cc (5A.5, \text{TBDY}) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.1216822$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.06722486$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.04168983$$

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) = 0.13664457

$\mu_u = M/R_c$ (4.15) = 7.0181E+008

$u = s_u$ (4.1) = 5.9114336E-005

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 535691.969$

Calculation of Shear Strength at edge 1, $V_{r1} = 535691.969$

$V_{r1} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w \cdot d) = 0.00331157$

A_s (tension reinf.) = 709.9999

$b_w = 400.00$

$d = 536.00$

$V_u \cdot d / \mu_u < 1 = 1.00$

$\mu_u = 1.1086E+006$

$V_u = 9840.633$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$

$V_{s1} = 311832.16$ is calculated for jacket, with:

$d = 536.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 150.00$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$V_{s2} = 29786.953$ is calculated for jacket, with:

$d_2 = 400.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 300.00$

V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

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

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

Calculation of Shear Strength at edge 2, $V_{r2} = 535691.969$

$V_{r2} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w \cdot d) = 0.00331157$

A_s (tension reinf.) = 709.9999

$b_w = 400.00$

d = 536.00
Vu*d/Mu < 1 = 1.00
Mu = 1.1086E+006
Vu = 9840.633

From (11.5.4.8), ACI 318-14: Vs1 + Vs2 = 341619.112

Vs1 = 311832.16 is calculated for jacket, with:

d = 536.00
Av = 157079.633
fy = 555.5556
s = 150.00

Vs1 has been multiplied by 1 (s < d/2, according to ASCE 41-17,10.3.4)

Vs2 = 29786.953 is calculated for jacket, with:

d = 400.00
Av = 100530.965
fy = 444.4444
s = 300.00

Vs2 has been multiplied by 2(1-s/d) (s > d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

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

From (11-11), ACI 440: Vs + Vf <= 755657.47

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjars

Constant Properties

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

Jacket

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

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

#####

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

Jacket

New material: Steel Strength, fs = 1.25*fsm = 694.4444

Existing Column

Existing material: Steel Strength, fs = 1.25*fsm = 555.5556

#####

External Height, H = 670.00

External Width, W = 400.00

Internal Height, H = 500.00

Internal Width, W = 200.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.03245

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.2127266E-014$
EDGE -B-
Shear Force, $V_b = -1.2127266E-014$
BOTH EDGES
Axial Force, $F = -2285.867$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 709.9999$
-Compression: $As_c = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 911.0619$
-Compression: $As_{c,com} = 911.0619$
-Middle: $As_{c,mid} = 556.0619$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.52117341$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 191881.096$
with
 $M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 2.8782E+008$
 $\mu_{1+} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{1-} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 2.8782E+008$
 $\mu_{2+} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $\mu_{2-} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 1.2127266E-014$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = -1.2127266E-014$, is the shear force acting at edge 2 for the the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 0.00010364$
 $\mu_u = 2.8782E+008$

with full section properties:

$b = 670.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.0002896$
 $N = 2285.867$
 $f_c = 33.00$
 $\epsilon_{co} (5A.5, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \max(\mu_u, \mu_{cc}) = 0.00646173$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00646173$
 $\mu_{we} (5.4c) = 0.00548239$
 $\mu_{ase} ((5.4d), TBDY) = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.14776895$
 $ase_1 = 0.14776895$

bo_1 = 340.00
ho_1 = 610.00
bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
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 = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
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 $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 647.5096$
 with $Es_2 = (Es_{jacket} \cdot A_{sl,com,jacket} + Es_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.194$
 $fyv = 655.995$
 $suv = 0.032$
 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 $fsv = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 655.995$
 with $Es_v = (Es_{jacket} \cdot A_{sl,mid,jacket} + Es_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07473725$
 $2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07473725$
 $v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.04621327$

and confined core properties:

$b = 610.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 34.07072$
 $cc (5A.5, TBDY) = 0.00232446$
 $c = \text{confinement factor} = 1.03245$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.0896195$
 $2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0896195$
 $v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.05541561$

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

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

$su (4.9) = 0.13515888$
 $Mu = MRc (4.14) = 2.8782E+008$
 $u = su (4.1) = 0.00010364$

 Calculation of ratio lb/ld

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

 Calculation of Mu_1 -

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

$u = 0.00010364$
 $Mu = 2.8782E+008$

 with full section properties:

$b = 670.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.0002896$
 $N = 2285.867$

$fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$

we (5.4c) = 0.00548239
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14776895
ase1 = 0.14776895
bo_1 = 340.00
ho_1 = 610.00
bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
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 $es_{2,nominal}$ 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 $fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 647.5096$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.194$

$fy_v = 655.995$

$suv = 0.032$

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 $fs_v = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 655.995$

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

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07473725$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07473725$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.0896195$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0896195$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.13515888

$Mu = MRc$ (4.14) = 2.8782E+008

$u = su$ (4.1) = 0.00010364

Calculation of ratio lb/ld

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

Calculation of Mu_{2+}

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

$u = 0.00010364$

$Mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$fc = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$
 we (5.4c) = 0.00548239
 ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$
 $ase1 = 0.14776895$
 $bo_1 = 340.00$
 $ho_1 = 610.00$
 $bi2_1 = 975400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.14776895$
 $bo_2 = 192.00$
 $ho_2 = 492.00$
 $bi2_2 = 557856.00$
 $psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 1.22434$

 $psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.16538$
 $ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00261799$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 670.00$
 $ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00062519$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 500.00$

 $psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 1.22434$
 $ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00156298$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00025008$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

 $A_{sec} = 268000.00$
 $s1 = 150.00$
 $s2 = 300.00$
 $fy_{we1} = 694.4444$
 $fy_{we2} = 555.5556$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00232446$
 $c = \text{confinement factor} = 1.03245$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 777.0115$
 $fy1 = 647.5096$
 $su1 = 0.032$

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 $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 647.5096$

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

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 777.0115$
 $fy2 = 647.5096$
 $su2 = 0.032$

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

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

$$s_u2 = 0.4 * e_{su2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2_nominal} = 0.08$,

For calculation of $e_{su2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s1,com,jacket} + f_{s,core} * A_{s1,com,core}) / A_{s1,com} = 647.5096$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.194$$

$$fy_v = 655.995$$

$$s_{uv} = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

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

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

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

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

For calculation of $e_{suv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s1,mid,jacket} + f_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 655.995$$

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

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.07473725$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.07473725$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.07072$$

$$c_c (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.0896195$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.0896195$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.13515888$$

$$\mu_u = M_{Rc} (4.14) = 2.8782E+008$$

$$u = s_u (4.1) = 0.00010364$$

Calculation of ratio l_b/l_d

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

Calculation of μ_u -

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

$$u = 0.00010364$$

$$\mu_u = 2.8782E+008$$

with full section properties:

$$b = 670.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0002896$$

$$N = 2285.867$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00646173$$

$$we (5.4c) = 0.00548239$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$$

$$ase1 = 0.14776895$$

$$bo_1 = 340.00$$

$$ho_1 = 610.00$$

$$bi2_1 = 975400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.14776895$$

$$bo_2 = 192.00$$

$$ho_2 = 492.00$$

$$bi2_2 = 557856.00$$

$$psh, \min * Fy_{we} = \text{Min}(psh, x * Fy_{we}, psh, y * Fy_{we}) = 1.22434$$

$$psh, x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.16538$$

$$ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00261799$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 670.00$$

$$ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00062519$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 500.00$$

$$psh, y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 1.22434$$

$$ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00156298$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00025008$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s1 = 150.00$$

$$s2 = 300.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_c = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } cc = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 777.0115$$

$$fy1 = 647.5096$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs, \text{jacket} * A_{sl, \text{ten, jacket}} + fs, \text{core} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 647.5096$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 777.0115$$

$$fy2 = 647.5096$$

$$su2 = 0.032$$

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

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

$$s_u2 = 0.4 * e_{s_u2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_u2,nominal} = 0.08$,

For calculation of $e_{s_u2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{s_y2} = f_{s_2}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s_2} = (f_{s,jacket} * A_{s_l,com,jacket} + f_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 647.5096$$

$$\text{with } E_{s_2} = (E_{s,jacket} * A_{s_l,com,jacket} + E_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.194$$

$$fy_v = 655.995$$

$$s_{u_v} = 0.032$$

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

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

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

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

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY

For calculation of $e_{s_{u_v},nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s_v} = (f_{s,jacket} * A_{s_l,mid,jacket} + f_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 655.995$$

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

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.07473725$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.07473725$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.0896195$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.0896195$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.13515888$$

$$\mu = M R_c (4.14) = 2.8782E+008$$

$$u = s_u (4.1) = 0.00010364$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 368171.311$

Calculation of Shear Strength at edge 1, $V_{r1} = 368171.311$

$V_{r1} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'V_w' is replaced by 'V_w + f * V_f'
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 182002.857$

= 1 (normal-weight concrete)
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 28.14925$, but $fc'^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)
 $pw = As / (bw \cdot d) = 0.00331157$
As (tension reinf.) = 709.9999
bw = 670.00
d = 320.00
 $Vu \cdot d / Mu < 1 = 0.00$
Mu = 2.3879272E-011
Vu = 1.2127266E-014
From (11.5.4.8), ACI 318-14: $Vs1 + Vs2 = 186168.454$
Vs1 = 186168.454 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 555.5556
s = 150.00
Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
Vs2 = 0.00 is calculated for jacket, with:
d2 = 160.00
Av = 100530.965
fy = 444.4444
s = 300.00
Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $Vs + Vf < = 755657.47$

Calculation of Shear Strength at edge 2, Vr2 = 368171.311
Vr2 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $Vc = 182002.857$
= 1 (normal-weight concrete)
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 28.14925$, but $fc'^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)
 $pw = As / (bw \cdot d) = 0.00331157$
As (tension reinf.) = 709.9999
bw = 670.00
d = 320.00
 $Vu \cdot d / Mu < 1 = 0.00$
Mu = 1.2499023E-011
Vu = 1.2127266E-014
From (11.5.4.8), ACI 318-14: $Vs1 + Vs2 = 186168.454$
Vs1 = 186168.454 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 555.5556
s = 150.00
Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
Vs2 = 0.00 is calculated for jacket, with:
d = 160.00
Av = 100530.965
fy = 444.4444
s = 300.00
Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $Vs + Vf < = 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1
At local axis: 3

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.9313521E-011$

Shear Force, $V_2 = -8.3688847E-015$

Shear Force, $V_3 = 5172.783$

Axial Force, $F = -6277.313$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 709.9999$

-Compression: $A_{slc} = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 911.0619$

-Compression: $A_{sl,com} = 911.0619$

-Middle: $A_{sl,mid} = 556.0619$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten,jacket} = 603.1858$

-Compression: $A_{sl,com,jacket} = 603.1858$

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle: $A_{sl,mid,core} = 153.938$

Mean Diameter of Tension Reinforcement, $DbL = 15.20$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \gamma * u = 0.00870385$

$u = \gamma * u_p = 0.00870385$

- Calculation of γ -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00370385 ((4.29), Biskinis Phd)$

My = 1.8672E+008
Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = 0.3*Ec*Ig = 2.5206E+013

Calculation of Yielding Moment My

Calculation of ϕ_y and My according to Annex 7 -

y = Min(y_{ten} , y_{com})
 $y_{ten} = 9.3764882E-006$
with $f_y = 555.5556$
d = 357.00
y = 0.22388433
A = 0.00999317
B = 0.00562063
with $p_t = 0.00380895$
pc = 0.00380895
pv = 0.00232477
N = 6277.313
b = 670.00
" = 0.12044818
 $y_{comp} = 2.7605333E-005$
with $f_c = 28.14925$
Ec = 26999.444
y = 0.22323917
A = 0.00988302
B = 0.00557012
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of ϕ_p -

From table 10-7: $\phi_p = 0.005$

with:

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.52117341$

- Transverse Reinforcement: NC

- Stirrup Spacing > d/3

- Low ductility demand, $\phi_y < 2$ (table 10-6, ASCE 41-17)

= 3.0408527E-022

- Stirrup Spacing <= d/2

d = d_external = 357.00

s = s_external = 150.00

- Strength provided by hoops $V_s < 3/4$ *design Shear

$V_s = 209998.016$, already given in calculation of shear control ratio

design Shear = 8.3688847E-015

- (ϕ_p)/ bal = -0.27559707

= $A_{sl}/(b_w*d) = 0.00296835$

Tension Reinf Area: $A_{sl} = 709.9999$

' = $A_{slc}/(b_w*d) = 0.00697431$

Compression Reinf Area: $A_{slc} = 1668.186$

From (B-1), ACI 318-11: bal = 0.01453557

$f_c = (f_{c_jacket}*Area_jacket + f_{c_core}*Area_core)/section_area = 28.14925$

$f_y = f_{y_jacket_bars} = 555.5556$

From 10.2.7.3, ACI 318-11: $\phi_p = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \phi_y) = 0.51923077$

$\phi_y = 0.00277778$

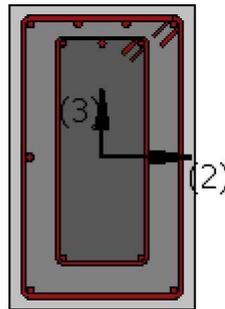
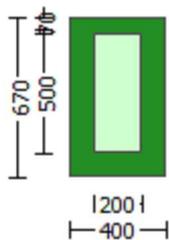
- $V/(b_w*d*f_c^{0.5}) = 7.9417160E-020$, NOTE: units in lb & in

bw = 670.00

End Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

beam B1, Floor 1
Limit State: Operational Level (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: beam JB1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.9313521E-011$
Shear Force, $V_a = -8.3688847E-015$
EDGE -B-
Bending Moment, $M_b = -5.9825082E-012$
Shear Force, $V_b = 8.3688847E-015$
BOTH EDGES
Axial Force, $F = -6277.313$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 911.0619$
-Compression: $A_{sc,com} = 911.0619$
-Middle: $A_{st,mid} = 556.0619$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 15.20$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 327136.349$
 V_n ((22.5.1.1), ACI 318-14) = 327136.349

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw + ϕV_f '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 159584.741$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 21.64179$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 670.00$
 $d = 320.00$
 $V_u \cdot d / M_u < 1 = 0.00$
 $M_u = 5.9825082E-012$
 $V_u = 8.3688847E-015$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 167551.608$
 $V_{s1} = 167551.608$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 300.00$
 V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: Vs + Vf <= 662579.716

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1
 At local axis: 2
 Integration Section: (b)

Calculation No. 6

beam B1, Floor 1

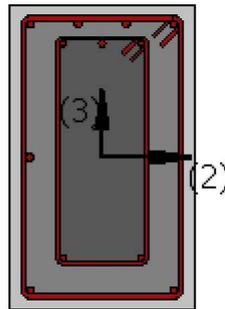
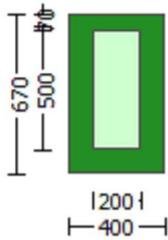
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

Existing Column

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

#####

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03245

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 9840.633$

EDGE -B-

Shear Force, $V_b = 9840.633$

BOTH EDGES

Axial Force, $F = -2285.867$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 709.9999$

-Compression: $A_{sc} = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, \text{ten}} = 709.9999$

-Compression: $A_{st, \text{com}} = 1266.062$

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

Calculation of Shear Capacity ratio , $V_e/V_r = 0.89177444$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 477716.403$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 7.0181E+008$

$M_{u1+} = 4.0754E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination

$M_{u1-} = 7.0181E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 7.0181E+008$

$M_{u2+} = 4.0754E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination

$M_{u2-} = 7.0181E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 9840.633$, is the shear force acting at edge 1 for the the static loading combination

$V_2 = 9840.633$, is the shear force acting at edge 2 for the the static loading combination

Calculation of M_{u1+}

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

$$u = 5.5992766E-005$$

$$Mu = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00646173$$

$$w_e(5.4c) = 0.00548239$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$$

$$ase1 = 0.14776895$$

$$bo_1 = 340.00$$

$$ho_1 = 610.00$$

$$bi2_1 = 975400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.14776895$$

$$bo_2 = 192.00$$

$$ho_2 = 492.00$$

$$bi2_2 = 557856.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.22434$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00261799$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 670.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00062519$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 500.00$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00156298$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00025008$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s1 = 150.00$$

$$s2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 761.0619$$

$$fy1 = 634.2183$$

$$su1 = 0.032$$

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 $es_{u1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_{y1} = fs_1/1.2$, from table 5.1, TBDY.

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

with $fs_1 = (fs_{jacket} \cdot A_{sl,ten,jacket} + fs_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 634.2183$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 772.5393$

$fy_2 = 643.7827$

$su_2 = 0.032$

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

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

$su_2 = 0.4 \cdot es_{u2_nominal} ((5.5), TBDY) = 0.032$

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_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 643.7827$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$suv = 0.032$

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

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

$suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

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

For calculation of $es_{uv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fs_{yv} = f_{sv}/1.2$, from table 5.1, TBDY.

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

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

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.0544071$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.09848107$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.03374084$

and confined core properties:

$b = 340.00$

$d = 597.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.06722486$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.1216822$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04168983$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.08851292$

$Mu = MRc (4.14) = 4.0754E+008$

$u = su (4.1) = 5.5992766E-005$

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:

$$u = 5.9114336E-005$$

$$\mu = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00646173$$

$$w_e (5.4c) = 0.00548239$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.22434$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$$

$$ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.00261799$$

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

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 670.00$$

$$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00062519$$

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

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 500.00$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$$

$$ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.00156298$$

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

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00025008$$

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

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s1 = 150.00$$

$$s2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 772.5393$$

$$fy1 = 643.7827$$

$$su1 = 0.032$$

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

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

$$s_u1 = 0.4 * e_{s1_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s1_nominal} = 0.08$,

For calculation of $e_{s1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 643.7827$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 761.0619$$

$$fy_2 = 634.2183$$

$$s_u2 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$$s_u2 = 0.4 * e_{s2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s2_nominal} = 0.08$,

For calculation of $e_{s2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 634.2183$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s,com,jacket} + E_{s,core} * A_{s,com,core}) / A_{s,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.3333$$

$$fy_v = 694.4444$$

$$s_uv = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

For calculation of $e_{suv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

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

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.09848107$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.0544071$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.07072$$

$$c_c (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.1216822$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.06722486$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.04168983$$

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

--->

$$s_u (4.8) = 0.13664457$$

$$\mu_u = M R_c (4.15) = 7.0181E+008$$

$$u = s_u (4.1) = 5.9114336E-005$$

Calculation of ratio l_b/l_d

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

Calculation of μ_{2+}

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

$$\mu = 5.5992766E-005$$

$$\mu = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00646173$$

$$\mu_{we} \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$f_{y1} = 634.2183$
 $s_{u1} = 0.032$
 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 $f_{s1} = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 634.2183$
 with $E_{s1} = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 772.5393$
 $f_{y2} = 643.7827$
 $s_{u2} = 0.032$
 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 $f_{s2} = (f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 643.7827$
 with $E_{s2} = (E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $f_{y_v} = 694.4444$
 $s_{u_v} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{u_v} = 0.4 * e_{s_{u_v,nominal}} ((5.5), TBDY) = 0.032$
 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 $f_{s_v} = (f_{s,jacket} * A_{s1,mid,jacket} + f_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 694.4444$
 with $E_{s_v} = (E_{s,jacket} * A_{s1,mid,jacket} + E_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 200000.00$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.0544071$
 $2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.09848107$
 $v = A_{s1,mid} / (b * d) * (f_{s_v} / f_c) = 0.03374084$
 and confined core properties:
 $b = 340.00$
 $d = 597.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.07072$
 $cc (5A.5, TBDY) = 0.00232446$
 $c = \text{confinement factor} = 1.03245$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.06722486$
 $2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.1216822$
 $v = A_{s1,mid} / (b * d) * (f_{s_v} / f_c) = 0.04168983$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $s_u (4.9) = 0.08851292$
 $M_u = M_{Rc} (4.14) = 4.0754E+008$
 $u = s_u (4.1) = 5.5992766E-005$

Calculation of ratio l_b/d

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

Calculation of μ_2

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

$$\mu = 5.9114336E-005$$

$$\mu = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00646173$$

$$\mu_{cc} \text{ (5.4c)} = 0.00548239$$

$$\text{ase} \text{ ((5.4d), TBDY)} = (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.14776895$$

$$\text{ase}_1 = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 1.22434$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.16538$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 1.22434$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

y1 = 0.0025
sh1 = 0.008
ft1 = 772.5393
fy1 = 643.7827
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 = 643.7827

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

y2 = 0.0025
sh2 = 0.008
ft2 = 761.0619
fy2 = 634.2183
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 = 634.2183

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

yv = 0.0025
shv = 0.008
ftv = 833.3333
fyv = 694.4444
suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107

2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822

2 = Asl,com/(b*d)*(fs2/fc) = 0.06722486

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

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

--->

$$s_u(4.8) = 0.13664457$$

$$\mu_u = M_{Rc}(4.15) = 7.0181E+008$$

$$u = s_u(4.1) = 5.9114336E-005$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 535691.969$

Calculation of Shear Strength at edge 1, $V_{r1} = 535691.969$

$$V_{r1} = V_n((22.5.1.1), \text{ACI } 318-14)$$

NOTE: In expression (22.5.1.1) 'V_w' is replaced by 'V_w + f*V_f'
where V_f is the contribution of FRPs (11.3), ACI 440).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 194072.856$$

= 1 (normal-weight concrete)

$$\text{Mean concrete strength: } f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w \cdot d) = 0.00331157$$

$$A_s (\text{tension reinf.}) = 709.9999$$

$$b_w = 400.00$$

$$d = 536.00$$

$$V_u \cdot d / \mu_u < 1 = 1.00$$

$$\mu_u = 1.1086E+006$$

$$V_u = 9840.633$$

$$\text{From (11.5.4.8), ACI 318-14: } V_{s1} + V_{s2} = 341619.112$$

$V_{s1} = 311832.16$ is calculated for jacket, with:

$$d = 536.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 150.00$$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$V_{s2} = 29786.953$ is calculated for jacket, with:

$$d_2 = 400.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 300.00$$

V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.50$$

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

$$\text{From (11-11), ACI } 440: V_s + V_f \leq 755657.47$$

Calculation of Shear Strength at edge 2, $V_{r2} = 535691.969$

$$V_{r2} = V_n((22.5.1.1), \text{ACI } 318-14)$$

NOTE: In expression (22.5.1.1) 'V_w' is replaced by 'V_w + f*V_f'
where V_f is the contribution of FRPs (11.3), ACI 440).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 194072.856$$

= 1 (normal-weight concrete)

$$\text{Mean concrete strength: } f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w \cdot d) = 0.00331157$$

$$A_s (\text{tension reinf.}) = 709.9999$$

$$b_w = 400.00$$

$$d = 536.00$$

$$V_u \cdot d / \mu_u < 1 = 1.00$$

$$\mu_u = 1.1086E+006$$

$$V_u = 9840.633$$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$

$V_{s1} = 311832.16$ is calculated for jacket, with:

$d = 536.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 150.00$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$V_{s2} = 29786.953$ is calculated for jacket, with:

$d = 400.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 300.00$

V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

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

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03245

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.2127266E-014$

EDGE -B-

Shear Force, $V_b = -1.2127266E-014$

BOTH EDGES

Axial Force, $F = -2285.867$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 709.9999$

-Compression: $As_c = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 911.0619$

-Compression: $As_{c,com} = 911.0619$

-Middle: $As_{mid} = 556.0619$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.52117341$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 191881.096$
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.8782E+008$

$Mu_{1+} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.8782E+008$

$Mu_{2+} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 1.2127266E-014$, is the shear force acting at edge 1 for the static loading combination

$V_2 = -1.2127266E-014$, is the shear force acting at edge 2 for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 0.00010364$

$M_u = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

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

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00646173$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00646173$

$w_e (5.4c) = 0.00548239$

$ase ((5.4d), TBDY) = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.14776895$

$ase_1 = 0.14776895$

$bo_1 = 340.00$

$ho_1 = 610.00$

$bi_{2,1} = 975400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.14776895$

bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
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 = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
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 = 647.5096

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

yv = 0.0025
shv = 0.008

$$ftv = 787.194$$

$$fyv = 655.995$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 655.995$$

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.07473725$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.07473725$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.0896195$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.0896195$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.13515888$$

$$Mu = MRc (4.14) = 2.8782E+008$$

$$u = su (4.1) = 0.00010364$$

Calculation of ratio lb/d

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

Calculation of $Mu1$ -

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

$$u = 0.00010364$$

$$Mu = 2.8782E+008$$

with full section properties:

$$b = 670.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0002896$$

$$N = 2285.867$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00646173$$

$$we (5.4c) = 0.00548239$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$$

$$ase1 = 0.14776895$$

$$bo_1 = 340.00$$

ho_1 = 610.00
bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
su1 = 0.032

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

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

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

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

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
su2 = 0.032

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

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

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

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

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

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096

with $E_s2 = (E_{s,jacket} \cdot A_{s1,com,jacket} + E_{s,core} \cdot A_{s1,com,core}) / A_{s1,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.194$
 $fy_v = 655.995$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{u,min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (f_{s,jacket} \cdot A_{s1,mid,jacket} + f_{s,mid} \cdot A_{s1,mid,core}) / A_{s1,mid} = 655.995$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s1,mid,jacket} + E_{s,mid} \cdot A_{s1,mid,core}) / A_{s1,mid} = 200000.00$
 $1 = A_{s1,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07473725$
 $2 = A_{s1,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07473725$
 $v = A_{s1,mid} / (b \cdot d) \cdot (fsv / fc) = 0.04621327$

and confined core properties:

$b = 610.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 34.07072$
 $cc (5A.5, TBDY) = 0.00232446$
 $c = \text{confinement factor} = 1.03245$
 $1 = A_{s1,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.0896195$
 $2 = A_{s1,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0896195$
 $v = A_{s1,mid} / (b \cdot d) \cdot (fsv / fc) = 0.05541561$

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

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

$su (4.9) = 0.13515888$
 $Mu = MRc (4.14) = 2.8782E+008$
 $u = su (4.1) = 0.00010364$

 Calculation of ratio lb/ld

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

 Calculation of Mu_{2+}

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

$u = 0.00010364$
 $Mu = 2.8782E+008$

 with full section properties:

$b = 670.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.0002896$
 $N = 2285.867$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$
 $we (5.4c) = 0.00548239$

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14776895
ase1 = 0.14776895
bo_1 = 340.00
ho_1 = 610.00
bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
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 = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
su2 = 0.032

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

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

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

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

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

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

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

with $f_{s2} = (f_{s,jacket} \cdot A_{s1,com,jacket} + f_{s,core} \cdot A_{s1,com,core})/A_{s1,com} = 647.5096$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.194$

$fy_v = 655.995$

$s_{uv} = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

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

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

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 655.995$

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 = $A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.07473725$

2 = $A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07473725$

v = $A_{s1,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04621327$

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

f_{cc} (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = $A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0896195$

2 = $A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0896195$

v = $A_{s1,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio l_b/l_d

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

Calculation of Mu2-

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

u = 0.00010364

Mu = 2.8782E+008

with full section properties:

b = 670.00

d = 357.00

d' = 43.00

v = 0.0002896

N = 2285.867

f_c = 33.00

co (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00646173$

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

From (5.4b), TBDY: $c_u = 0.00646173$

w_e (5.4c) = 0.00548239

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$

$a_{se1} = 0.14776895$

$b_{o_1} = 340.00$

$h_{o_1} = 610.00$

$b_{i2_1} = 975400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$

$b_{o_2} = 192.00$

$h_{o_2} = 492.00$

$b_{i2_2} = 557856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$

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

No stirups, $n_{s_1} = 2.00$

$h_1 = 670.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$

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

No stirups, $n_{s_2} = 2.00$

$h_2 = 500.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$

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

No stirups, $n_{s_1} = 2.00$

$h_1 = 400.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$

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

No stirups, $n_{s_2} = 2.00$

$h_2 = 200.00$

$A_{sec} = 268000.00$

$s_1 = 150.00$

$s_2 = 300.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00232446$

c = confinement factor = 1.03245

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 777.0115$

$fy_1 = 647.5096$

$su_1 = 0.032$

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

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

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

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

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

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

with $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 647.5096$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 777.0115$

$fy_2 = 647.5096$

$su_2 = 0.032$

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

$$\text{with } fs_2 = (fs_{jacket} * Asl_{,com,jacket} + fs_{core} * Asl_{,com,core}) / Asl_{,com} = 647.5096$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.194$$

$$fy_v = 655.995$$

$$suv = 0.032$$

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

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

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl_{,mid,jacket} + fs_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 655.995$$

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

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.07473725$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.07473725$$

$$v = Asl_{,mid} / (b * d) * (fsv / fc) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.0896195$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.0896195$$

$$v = Asl_{,mid} / (b * d) * (fsv / fc) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.13515888$$

$$Mu = MRc (4.14) = 2.8782E+008$$

$$u = su (4.1) = 0.00010364$$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 368171.311$

Calculation of Shear Strength at edge 1, $V_{r1} = 368171.311$

$$V_{r1} = V_n ((22.5.1.1), ACI 318-14)$$

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 182002.857$$

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

$$\text{Mean concrete strength: } fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 28.14925, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$pw = As / (bw * d) = 0.00331157$$

As (tension reinf.) = 709.9999

bw = 670.00

d = 320.00

$V_u*d/\mu < 1 = 0.00$

$\mu = 2.3879272E-011$

$V_u = 1.2127266E-014$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 186168.454$

$V_{s1} = 186168.454$ is calculated for jacket, with:

d = 320.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 150.00

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

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

d2 = 160.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 300.00

V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

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

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

Calculation of Shear Strength at edge 2, $V_{r2} = 368171.311$

$V_{r2} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f*V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 182002.857$

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket}*Area_jacket + f'_{c_core}*Area_core)/Area_section = 28.14925$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$p_w = A_s/(b_w*d) = 0.00331157$

As (tension reinf.) = 709.9999

bw = 670.00

d = 320.00

$V_u*d/\mu < 1 = 0.00$

$\mu = 1.2499023E-011$

$V_u = 1.2127266E-014$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 186168.454$

$V_{s1} = 186168.454$ is calculated for jacket, with:

d = 320.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 150.00

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

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

d = 160.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 300.00

V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

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

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\phi = 1.00$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 670.00$
 External Width, $W = 400.00$
 Internal Height, $H = 500.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d > 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 9.6669E+006$
 Shear Force, $V_2 = 8.3688847E-015$
 Shear Force, $V_3 = 14508.483$
 Axial Force, $F = -6277.313$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 709.9999$
 -Compression: $A_{sc} = 1668.186$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 709.9999$
 -Compression: $A_{sc,com} = 1266.062$
 -Middle: $A_{sc,mid} = 402.1239$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,jacket} = 402.1239$
 -Compression: $A_{sc,com,jacket} = 804.2477$
 -Middle: $A_{sc,mid,jacket} = 402.1239$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,core} = 307.8761$
 -Compression: $A_{sc,com,core} = 461.8141$
 -Middle: $A_{sc,mid,core} = 0.00$
 Mean Diameter of Tension Reinforcement, $D_bL = 15.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = \phi \cdot u = 0.01073613$
 $u = y + p = 0.01073613$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00073613$ ((4.29), Biskinis Phd)
 $M_y = 2.5663E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 666.2906
 From table 10.5, ASCE 41_17: $E_{eff} = 0.3 \cdot E_c \cdot I_g = 7.7426E+013$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 5.0856178E-006$
with $f_y = 555.5556$
 $d = 627.00$
 $y = 0.18525141$
 $A = 0.00953057$
 $B = 0.00408197$
with $p_t = 0.00283094$
 $p_c = 0.00504809$
 $p_v = 0.00160336$
 $N = 6277.313$
 $b = 400.00$
 $\rho = 0.06858054$
 $y_{\text{comp}} = 1.9026758E-005$
with $f_c = 28.14925$
 $E_c = 26999.444$
 $y = 0.18441629$
 $A = 0.00942552$
 $B = 0.0040338$
with $E_s = 200000.00$

Calculation of ratio l_b/d

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

- Calculation of ρ -

From table 10-7: $\rho = 0.01$

with:

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.89177444$

- Transverse Reinforcement: C

- Stirrup Spacing $\leq d/3$

- Low ductility demand, $\rho_y < 2$ (table 10-6, ASCE 41-17)

$\rho = -2.1279462E-007$

- Stirrup Spacing $\leq d/2$

$d = d_{\text{external}} = 627.00$

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

- Strength provided by hoops $V_s < 3/4 \cdot \text{design Shear}$

$V_s = 371406.065$, already given in calculation of shear control ratio

design Shear = 14508.483

- ($\rho - \rho'$)/ $\rho_{\text{bal}} = -0.26283917$

$\rho = A_{\text{st}}/(b_w \cdot d) = 0.00283094$

Tension Reinf Area: $A_{\text{st}} = 709.9999$

$\rho' = A_{\text{sc}}/(b_w \cdot d) = 0.00665146$

Compression Reinf Area: $A_{\text{sc}} = 1668.186$

From (B-1), ACI 318-11: $\rho_{\text{bal}} = 0.01453557$

$f_c = (f_{c,\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_{c,\text{core}} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 28.14925$

$f_y = f_{y,\text{jacket_bars}} = 555.5556$

From 10.2.7.3, ACI 318-11: $\rho_1 = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000 / (87000 + f_y) = c_b/d_t = 0.003 / (0.003 + \rho_y) = 0.51923077$

$\rho_y = 0.00277778$

- $V / (b_w \cdot d \cdot f_c^{0.5}) = 0.1313059$, NOTE: units in lb & in

$b_w = 400.00$

End Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 7

beam B1, Floor 1

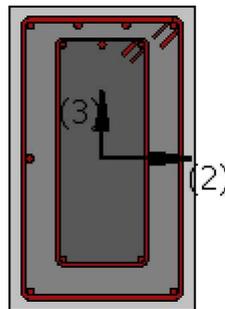
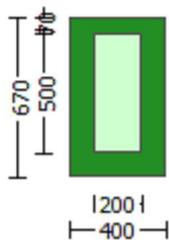
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjars

Constant Properties

Knowledge Factor, $k = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = 4.3370E+006$
Shear Force, $V_a = 5172.783$
EDGE -B-
Bending Moment, $M_b = 9.6669E+006$
Shear Force, $V_b = 14508.483$
BOTH EDGES
Axial Force, $F = -6277.313$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{s,t} = 709.9999$
-Compression: $A_{s,c} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 709.9999$
-Compression: $A_{s,com} = 1266.062$
-Middle: $A_{s,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 15.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = *V_n = 476751.699$
 V_n ((22.5.1.1), ACI 318-14) = 476751.699

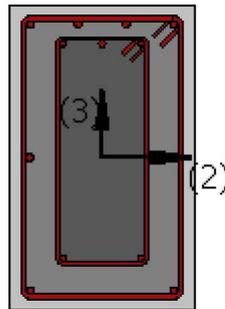
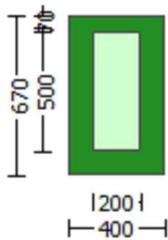
NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f*V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 169294.498$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 21.64179$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w * d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u * d / M_u < 1 = 0.80445384$
 $M_u = 9.6669E+006$
 $V_u = 14508.483$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 307457.201$
 $V_{s1} = 280648.944$ is calculated for jacket, with:
 $d = 536.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 26808.257$ is calculated for core, with:
 $d = 400.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 300.00$
 V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 662579.716$

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

beam B1, Floor 1
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Chord rotation capacity (μ)
Edge: End
Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjars

Constant Properties

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

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

External Height, $H = 670.00$
External Width, $W = 400.00$
Internal Height, $H = 500.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.03245
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou, \min} >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 9840.633$
EDGE -B-
Shear Force, $V_b = 9840.633$
BOTH EDGES
Axial Force, $F = -2285.867$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st, \text{ten}} = 709.9999$
-Compression: $A_{sl, \text{com}} = 1266.062$
-Middle: $A_{sl, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.89177444$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 477716.403$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 7.0181E+008$
 $\mu_{u1+} = 4.0754E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 7.0181E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 7.0181E+008$
 $\mu_{u2+} = 4.0754E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 7.0181E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 9840.633$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = 9840.633$, is the shear force acting at edge 2 for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 5.5992766E-005$

Mu = 4.0754E+008

with full section properties:

b = 400.00

d = 627.00

d' = 43.00

v = 0.00027619

N = 2285.867

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$

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

From (5.4b), TBDY: $cu = 0.00646173$

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$

ase1 = 0.14776895

bo_1 = 340.00

ho_1 = 610.00

bi2_1 = 975400.00

ase2 = $\text{Max}(ase1, ase2) = 0.14776895$

bo_2 = 192.00

ho_2 = 492.00

bi2_2 = 557856.00

$psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.22434$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00261799$

Ash1 = $A_{stir,1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 670.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00062519$

Ash2 = $A_{stir,2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 500.00

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00156298$

Ash1 = $A_{stir,1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 400.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00025008$

Ash2 = $A_{stir,2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: $cc = 0.00232446$

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 761.0619

fy1 = 634.2183

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.

$$\text{with } fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 634.2183$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 772.5393$$

$$fy2 = 643.7827$$

$$su2 = 0.032$$
 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.

$$\text{with } fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 643.7827$$

$$\text{with } Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00

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

$$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

$$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.0544071$$

$$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.09848107$$

$$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.03374084$$
 and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.06722486$$

$$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.1216822$$

$$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04168983$$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.08851292$
 $Mu = MRc (4.14) = 4.0754E+008$
 $u = su (4.1) = 5.5992766E-005$

 Calculation of ratio lb/ld

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

 Calculation of $Mu1$ -

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

$$u = 5.9114336E-005$$

$$Mu = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00646173$$

$$\phi_{we} \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy_1 = 643.7827$$

$$su_1 = 0.032$$

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

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

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

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

For calculation of $es1_{nominal}$ 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 $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 643.7827$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 761.0619$

$fy2 = 634.2183$

$su2 = 0.032$

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

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

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

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 $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 634.2183$

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

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.3333$

$fyv = 694.4444$

$suv = 0.032$

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

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

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

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

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.09848107$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.0544071$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.03374084$

and confined core properties:

$b = 340.00$

$d = 597.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.1216822$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.06722486$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04168983$

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

--->

$su (4.8) = 0.13664457$

$Mu = MRc (4.15) = 7.0181E+008$

$u = su (4.1) = 5.9114336E-005$

Calculation of ratio lb/ld

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

Calculation of Mu2+

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

$$\phi_u = 5.5992766E-005$$

$$\mu = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00646173$$

$$w_e \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o1} = 340.00$$

$$h_{o1} = 610.00$$

$$b_{i21} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o2} = 192.00$$

$$h_{o2} = 492.00$$

$$b_{i22} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

$$\text{No stirrups, } n_{s, 1} = 2.00$$

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

$$\text{No stirrups, } n_{s, 2} = 2.00$$

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

$$\text{No stirrups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

$$\text{No stirrups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$$fy_1 = 634.2183$$

$$su_1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 634.2183

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

y2 = 0.0025

sh2 = 0.008

ft2 = 772.5393

fy2 = 643.7827

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 = 643.7827

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0544071

2 = Asl,com/(b*d)*(fs2/fc) = 0.09848107

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06722486

2 = Asl,com/(b*d)*(fs2/fc) = 0.1216822

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.08851292

Mu = MRc (4.14) = 4.0754E+008

u = su (4.1) = 5.5992766E-005

Calculation of ratio lb/ld

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

Calculation of μ_2 -

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

$$\mu = 5.9114336E-005$$

$$\mu = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00646173$$

$$\mu_{we} \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy1 = 643.7827$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 643.7827$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 761.0619$$

$$fy2 = 634.2183$$

$$su2 = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 634.2183$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06722486$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983$$

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

---->

$$su (4.8) = 0.13664457$$

$$\begin{aligned}\mu &= MRC(4.15) = 7.0181E+008 \\ u &= su(4.1) = 5.9114336E-005\end{aligned}$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 535691.969$

Calculation of Shear Strength at edge 1, $V_{r1} = 535691.969$
 $V_{r1} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'V_w' is replaced by 'V_w + f*V_f'
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} * \text{Area}_{jacket} + f'_{c_core} * \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w * d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u * d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
 $V_u = 9840.633$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
 $d = 536.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 29786.953$ is calculated for jacket, with:
 $d_2 = 400.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 300.00$
 V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

Calculation of Shear Strength at edge 2, $V_{r2} = 535691.969$
 $V_{r2} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'V_w' is replaced by 'V_w + f*V_f'
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} * \text{Area}_{jacket} + f'_{c_core} * \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w * d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u * d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
 $V_u = 9840.633$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
 $d = 536.00$

Av = 157079.633
fy = 555.5556
s = 150.00

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
Vs2 = 29786.953 is calculated for jacket, with:

d = 400.00
Av = 100530.965
fy = 444.4444
s = 300.00

Vs2 has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

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

From (11-11), ACI 440: $Vs + Vf \leq 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.03245

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.2127266E-014$

EDGE -B-

Shear Force, $V_b = -1.2127266E-014$

BOTH EDGES

Axial Force, $F = -2285.867$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 709.9999$

-Compression: $A_{sc} = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 911.0619$

-Compression: $A_{sl,com} = 911.0619$

-Middle: $A_{sl,mid} = 556.0619$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.52117341$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 191881.096$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.8782E+008$

$M_{u1+} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.8782E+008$

$M_{u2+} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 1.2127266E-014$, is the shear force acting at edge 1 for the the static loading combination

$V_2 = -1.2127266E-014$, is the shear force acting at edge 2 for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 0.00010364$

$M_u = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00646173$

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

From (5.4b), TBDY: $\phi_u = 0.00646173$

w_e (5.4c) = 0.00548239

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.14776895$

$a_{se1} = 0.14776895$

$b_{o_1} = 340.00$

$h_{o_1} = 610.00$

$b_{i2_1} = 975400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$

$b_{o_2} = 192.00$

$h_{o_2} = 492.00$

$b_{i2_2} = 557856.00$

$$psh_{min} * Fywe = \text{Min}(psh_x * Fywe, psh_y * Fywe) = 1.22434$$

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.16538$$

ps1 (external) = $(Ash1 * h1 / s1) / Asec = 0.00261799$
Ash1 = Astir_1 * ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00

ps2 (internal) = $(Ash2 * h2 / s2) / Asec = 0.00062519$
Ash2 = Astir_2 * ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.22434$$

ps1 (external) = $(Ash1 * h1 / s1) / Asec = 0.00156298$
Ash1 = Astir_1 * ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = $(Ash2 * h2 / s2) / Asec = 0.00025008$
Ash2 = Astir_2 * ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

$$Asec = 268000.00$$

$$s1 = 150.00$$

$$s2 = 300.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 777.0115$$

$$fy1 = 647.5096$$

$$su1 = 0.032$$

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

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

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

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.

$$\text{with } fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 647.5096$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 777.0115$$

$$fy2 = 647.5096$$

$$su2 = 0.032$$

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

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

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

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.

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 647.5096$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.194$$

$$fyv = 655.995$$

$$suv = 0.032$$

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 $f_{syv} = f_{sv}/1.2$, 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 $f_{syv} = f_{sv}/1.2$, 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 $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 655.995$

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

$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.07473725$

$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.07473725$

$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.0896195$

$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.0896195$

$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$s_u (4.9) = 0.13515888$

$M_u = MR_c (4.14) = 2.8782E+008$

$u = s_u (4.1) = 0.00010364$

Calculation of ratio l_b/l_d

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

Calculation of M_u1 -

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

$u = 0.00010364$

$M_u = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

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

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$

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

From (5.4b), TBDY: $cu = 0.00646173$

$w_e (5.4c) = 0.00548239$

$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$

$ase1 = 0.14776895$

$bo_1 = 340.00$

$ho_1 = 610.00$

$bi2_1 = 975400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.14776895$

bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
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 = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
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 = 647.5096

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

yv = 0.0025
shv = 0.008

$$ftv = 787.194$$

$$fyv = 655.995$$

$$suv = 0.032$$

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.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 655.995$$

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.07473725$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.07473725$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.0896195$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.0896195$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.13515888$$

$$Mu = MRc (4.14) = 2.8782E+008$$

$$u = su (4.1) = 0.00010364$$

Calculation of ratio lb/ld

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

Calculation of Mu_{2+}

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

$$u = 0.00010364$$

$$Mu = 2.8782E+008$$

with full section properties:

$$b = 670.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0002896$$

$$N = 2285.867$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00646173$$

$$we (5.4c) = 0.00548239$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$$

$$ase1 = 0.14776895$$

$$bo_1 = 340.00$$

ho_1 = 610.00
bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
su1 = 0.032

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

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

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096

with $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.194$
 $fy_v = 655.995$
 $suv = 0.032$
 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 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 $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 655.995$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07473725$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07473725$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.04621327$

and confined core properties:

$b = 610.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 34.07072$
 $cc (5A.5, TBDY) = 0.00232446$
 $c = \text{confinement factor} = 1.03245$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.0896195$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0896195$
 $v = A_{s,mid} / (b \cdot d) \cdot (fsv / fc) = 0.05541561$

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

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

$su (4.9) = 0.13515888$
 $Mu = MRc (4.14) = 2.8782E+008$
 $u = su (4.1) = 0.00010364$

 Calculation of ratio lb/ld

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

 Calculation of Mu_2 -

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

$u = 0.00010364$
 $Mu = 2.8782E+008$

 with full section properties:

$b = 670.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.0002896$
 $N = 2285.867$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$
 $we (5.4c) = 0.00548239$

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14776895
ase1 = 0.14776895
bo_1 = 340.00
ho_1 = 610.00
bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 777.0115

fy1 = 647.5096

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 = 647.5096

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

y2 = 0.0025

sh2 = 0.008

ft2 = 777.0115

fy2 = 647.5096

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 $fs_2 = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 647.5096$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.194$

$fy_v = 655.995$

$suv = 0.032$

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 $fs_v = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

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

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

with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 655.995$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07473725$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07473725$

$v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.0896195$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0896195$

$v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.13515888

$Mu = MRc$ (4.14) = 2.8782E+008

$u = su$ (4.1) = 0.00010364

Calculation of ratio lb/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 368171.311$

Calculation of Shear Strength at edge 1, $V_{r1} = 368171.311$

$V_{r1} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 182002.857$

= 1 (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 28.14925$, but $fc'^{0.5} < =$
8.3 MPa (22.5.3.1, ACI 318-14)

$pw = As / (bw \cdot d) = 0.00331157$

As (tension reinf.) = 709.9999

$bw = 670.00$

$d = 320.00$

$$V_u \cdot d / \mu < 1 = 0.00$$

$$\mu = 2.3879272E-011$$

$$V_u = 1.2127266E-014$$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 186168.454$

$V_{s1} = 186168.454$ is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 150.00$$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

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

$$d_2 = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 300.00$$

V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

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

$$\text{From } (11-11), \text{ACI } 440: V_s + V_f \leq 755657.47$$

Calculation of Shear Strength at edge 2, $V_{r2} = 368171.311$

$$V_{r2} = V_n ((22.5.1.1), \text{ACI } 318-14)$$

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$$\text{From Table } (22.5.5.1), \text{ACI } 318-14: V_c = 182002.857$$

= 1 (normal-weight concrete)

$$\text{Mean concrete strength: } f'_c = (f'_{c'} \cdot \text{Area}_{\text{jacket}} + f'_{c'} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.14925, \text{ but } f_c^{0.5} < = 8.3 \text{ MPa } (22.5.3.1, \text{ACI } 318-14)$$

$$p_w = A_s / (b_w \cdot d) = 0.00331157$$

$$A_s (\text{tension reinf.}) = 709.9999$$

$$b_w = 670.00$$

$$d = 320.00$$

$$V_u \cdot d / \mu < 1 = 0.00$$

$$\mu = 1.2499023E-011$$

$$V_u = 1.2127266E-014$$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 186168.454$

$V_{s1} = 186168.454$ is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 150.00$$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 300.00$$

V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

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

$$\text{From } (11-11), \text{ACI } 440: V_s + V_f \leq 755657.47$$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -5.9825082E-012$

Shear Force, $V_2 = 8.3688847E-015$

Shear Force, $V_3 = 14508.483$

Axial Force, $F = -6277.313$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 709.9999$

-Compression: $As_c = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 911.0619$

-Compression: $As_{c,com} = 911.0619$

-Middle: $As_{mid} = 556.0619$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 603.1858$

-Compression: $As_{c,com,jacket} = 603.1858$

-Middle: $As_{mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $As_{c,com,core} = 307.8761$

-Middle: $As_{mid,core} = 153.938$

Mean Diameter of Tension Reinforcement, $Db_L = 15.20$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.00870385$

$u = y + p = 0.00870385$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00370385$ ((4.29), Biskinis Phd))

$M_y = 1.8672E+008$

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

From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 2.5206E+013$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 9.3764882\text{E-}006$
with $f_y = 555.5556$
 $d = 357.00$
 $y = 0.22388433$
 $A = 0.00999317$
 $B = 0.00562063$
with $p_t = 0.00380895$
 $p_c = 0.00380895$
 $p_v = 0.00232477$
 $N = 6277.313$
 $b = 670.00$
 $\rho = 0.12044818$
 $y_{\text{comp}} = 2.7605333\text{E-}005$
with $f_c = 28.14925$
 $E_c = 26999.444$
 $y = 0.22323917$
 $A = 0.00988302$
 $B = 0.00557012$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

- Calculation of ρ_p -

From table 10-7: $\rho_p = 0.005$

with:

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.52117341$

- Transverse Reinforcement: NC

- Stirrup Spacing $> d/3$

- Low ductility demand, $\rho_p / \rho_y < 2$ (table 10-6, ASCE 41-17)

$= 1.0821584\text{E-}021$

- Stirrup Spacing $\leq d/2$

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

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

- Strength provided by hoops $V_s < 3/4$ *design Shear

$V_s = 209998.016$, already given in calculation of shear control ratio

design Shear = $8.3688847\text{E-}015$

- ($\rho_p - \rho_y$)/ $\rho_{\text{bal}} = -0.27559707$

$= A_{s1}/(b_w*d) = 0.00296835$

Tension Reinf Area: $A_{s1} = 709.9999$

$\rho_c = A_{s2}/(b_w*d) = 0.00697431$

Compression Reinf Area: $A_{s2} = 1668.186$

From (B-1), ACI 318-11: $\rho_{\text{bal}} = 0.01453557$

$f_c = (f_{c_{\text{jacket}}*Area_{\text{jacket}} + f_{c_{\text{core}}*Area_{\text{core}}})/section_area = 28.14925$

$f_y = f_{y_{\text{jacket_bars}}} = 555.5556$

From 10.2.7.3, ACI 318-11: $\rho_1 = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \rho_y) = 0.51923077$

$\rho_y = 0.00277778$

- $V/(b_w*d*f_c^{0.5}) = 7.9417160\text{E-}020$, NOTE: units in lb & in

$b_w = 670.00$

End Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 9

beam B1, Floor 1

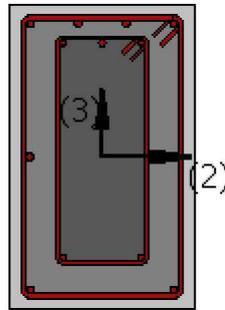
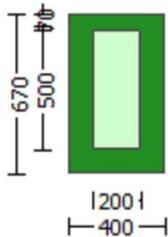
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

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

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -2.9386296E-011$
Shear Force, $V_a = -1.3148690E-014$
EDGE -B-
Bending Moment, $M_b = -1.0292494E-011$
Shear Force, $V_b = 1.3148690E-014$
BOTH EDGES
Axial Force, $F = -7208.138$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 911.0619$
-Compression: $A_{sl,com} = 911.0619$
-Middle: $A_{sl,mid} = 556.0619$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 15.20$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = *V_n = 327136.349$
 V_n ((22.5.1.1), ACI 318-14) = 327136.349

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 159584.741$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 21.64179$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = A_s / (b_w * d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 670.00$
 $d = 320.00$
 $V_u * d / M_u < 1 = 0.00$
 $M_u = 2.9386296E-011$
 $V_u = 1.3148690E-014$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 167551.608$
 $V_{s1} = 167551.608$ is calculated for jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 300.00$
 V_{s2} is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 662579.716$

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

beam B1, Floor 1

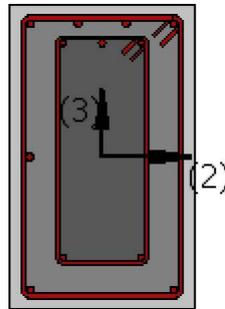
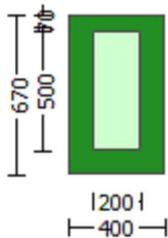
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03245
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min > = 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 9840.633$
EDGE -B-
Shear Force, $V_b = 9840.633$
BOTH EDGES
Axial Force, $F = -2285.867$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 709.9999$
-Compression: $A_{sc,com} = 1266.062$
-Middle: $A_{sc,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.89177444$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u * l_n / 2 = 477716.403$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 7.0181E+008$
 $Mu_{1+} = 4.0754E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $Mu_{1-} = 7.0181E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 7.0181E+008$
 $Mu_{2+} = 4.0754E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $Mu_{2-} = 7.0181E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
and
 $\pm w_u * l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 9840.633$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = 9840.633$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 5.5992766E-005$
 $Mu = 4.0754E+008$

with full section properties:
 $b = 400.00$

$d = 627.00$
 $d' = 43.00$
 $v = 0.00027619$
 $N = 2285.867$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$
 $we (5.4c) = 0.00548239$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$
 $ase1 = 0.14776895$
 $bo_1 = 340.00$
 $ho_1 = 610.00$
 $bi2_1 = 975400.00$
 $ase2 = Max(ase1, ase2) = 0.14776895$
 $bo_2 = 192.00$
 $ho_2 = 492.00$
 $bi2_2 = 557856.00$
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.22434$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00261799$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 670.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00062519$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 500.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00156298$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00025008$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 268000.00$
 $s1 = 150.00$
 $s2 = 300.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00232446$
 $c = confinement\ factor = 1.03245$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 761.0619$
 $fy1 = 634.2183$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/d = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 634.2183$
 with $Es1 = (Es, jacket * A_{sl, ten, jacket} + Es, core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$

$$ft2 = 772.5393$$

$$fy2 = 643.7827$$

$$su2 = 0.032$$

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.

$$\text{with } fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 643.7827$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.0544071$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09848107$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.06722486$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.1216822$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.04168983$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$su (4.9) = 0.08851292$$

$$Mu = MRc (4.14) = 4.0754E+008$$

$$u = su (4.1) = 5.5992766E-005$$

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:

$$u = 5.9114336E-005$$

$$Mu = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00646173$$

$$w_e (5.4c) = 0.00548239$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.16538$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 1.22434$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy_1 = 643.7827$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = (fs_{\text{jacket}} * A_{sl, \text{ten, jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 643.7827$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 761.0619$$

$$fy2 = 634.2183$$

$$su2 = 0.032$$
 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

$$lo/lo_{\text{ou,min}} = lb/lb_{\text{min}} = 1.00$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$
 From table 5A.1, TBDY: $esu2_{\text{nominal}} = 0.08$,
 For calculation of $esu2_{\text{nominal}}$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl_{\text{com,jacket}} + fs_{\text{core}} \cdot Asl_{\text{com,core}}) / Asl_{\text{com}} = 634.2183$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl_{\text{com,jacket}} + Es_{\text{core}} \cdot Asl_{\text{com,core}}) / Asl_{\text{com}} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00

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

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$
 From table 5A.1, TBDY: $esuv_{\text{nominal}} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{\text{nominal}}$ and 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.

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

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

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs1 / fc) = 0.09848107$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs2 / fc) = 0.0544071$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.03374084$$
 and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 34.07072$$

$$cc (5A.5, \text{TBDY}) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs1 / fc) = 0.1216822$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs2 / fc) = 0.06722486$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.04168983$$
 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
 ---->

$$su (4.8) = 0.13664457$$

$$Mu = MRc (4.15) = 7.0181E+008$$

$$u = su (4.1) = 5.9114336E-005$$

 Calculation of ratio lb/ld

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

 Calculation of $Mu2+$

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

$$u = 5.5992766E-005$$

$$\mu = 4.0754E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00646173$$

$$\phi_{we} \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_{cc} = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$$fy_1 = 634.2183$$

$$su_1 = 0.032$$

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

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

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

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 $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 634.2183$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 772.5393$

$fy2 = 643.7827$

$su2 = 0.032$

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 $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 643.7827$

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

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.3333$

$fyv = 694.4444$

$suv = 0.032$

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

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

$Shear_factor = 1.00$

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

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

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

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

For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered

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

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

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

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.0544071$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.09848107$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.03374084$

and confined core properties:

$b = 340.00$

$d = 597.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

$c =$ confinement factor = 1.03245

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.06722486$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.1216822$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04168983$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.08851292

$Mu = MRc$ (4.14) = 4.0754E+008

$u = su$ (4.1) = 5.5992766E-005

Calculation of ratio lb/ld

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

Calculation of Mu2-

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

$$\mu = 5.9114336E-005$$

$$\text{Mu} = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.00646173$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.00646173$$

$$w_e \text{ (5.4c)} = 0.00548239$$

$$a_s \text{ ((5.4d), TBDY)} = (a_{s1} * A_{ext} + a_{s2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{s1} = 0.14776895$$

$$b_{o1} = 340.00$$

$$h_{o1} = 610.00$$

$$b_{i21} = 975400.00$$

$$a_{s2} = \text{Max}(a_{s1}, a_{s2}) = 0.14776895$$

$$b_{o2} = 192.00$$

$$h_{o2} = 492.00$$

$$b_{i22} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

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

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

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

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

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

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy_1 = 643.7827$$

$$su_1 = 0.032$$

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 = 643.7827

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

y2 = 0.0025

sh2 = 0.008

ft2 = 761.0619

fy2 = 634.2183

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 = 634.2183

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

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107

2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822

2 = Asl,com/(b*d)*(fs2/fc) = 0.06722486

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

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) = 0.13664457

Mu = MRc (4.15) = 7.0181E+008

u = su (4.1) = 5.9114336E-005

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 535691.969$

Calculation of Shear Strength at edge 1, $V_{r1} = 535691.969$
 $V_{r1} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f'_c^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)
 $p_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u \cdot d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
 $V_u = 9840.633$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
 $d = 536.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 29786.953$ is calculated for jacket, with:
 $d_2 = 400.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 300.00$
 V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f < = 755657.47$

Calculation of Shear Strength at edge 2, $V_{r2} = 535691.969$
 $V_{r2} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f'_c^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)
 $p_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u \cdot d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
 $V_u = 9840.633$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
 $d = 536.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 29786.953 is calculated for jacket, with:
d = 400.00
Av = 100530.965
fy = 444.4444
s = 300.00
Vs2 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)
2(1-s/d) = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 755657.47

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03245
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2127266E-014
EDGE -B-
Shear Force, Vb = -1.2127266E-014

BOTH EDGES

Axial Force, $F = -2285.867$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 709.9999$

-Compression: $As_c = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 911.0619$

-Compression: $As_{c,com} = 911.0619$

-Middle: $As_{mid} = 556.0619$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.52117341$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 191881.096$
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.8782E+008$

$Mu_{1+} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.8782E+008$

$Mu_{2+} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 1.2127266E-014$, is the shear force acting at edge 1 for the the static loading combination

$V_2 = -1.2127266E-014$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 0.00010364$

$M_u = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00646173$

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

From (5.4b), TBDY: $\phi_u = 0.00646173$

w_e (5.4c) = 0.00548239

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.14776895$

$a_{se1} = 0.14776895$

$bo_1 = 340.00$

$ho_1 = 610.00$

$bi2_1 = 975400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$

$bo_2 = 192.00$

$ho_2 = 492.00$

$bi2_2 = 557856.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 1.22434$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 2.16538$

p_{s1} (external) = $(A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00261799$

Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

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

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096

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

yv = 0.0025
shv = 0.008
ftv = 787.194
fyv = 655.995
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

$$\text{with } fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 655.995$$

$$\text{with } Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.07473725$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.07473725$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl_ten / (b * d) * (fs1 / fc) = 0.0896195$$

$$2 = Asl_com / (b * d) * (fs2 / fc) = 0.0896195$$

$$v = Asl_mid / (b * d) * (fsv / fc) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.13515888$$

$$Mu = MRc (4.14) = 2.8782E+008$$

$$u = su (4.1) = 0.00010364$$

Calculation of ratio lb/ld

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

Calculation of $Mu1$ -

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

$$u = 0.00010364$$

$$Mu = 2.8782E+008$$

with full section properties:

$$b = 670.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0002896$$

$$N = 2285.867$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$$

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

From (5.4b), TBDY: $cu = 0.00646173$

$$we (5.4c) = 0.00548239$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.14776895$$

$$ase1 = 0.14776895$$

$$bo_1 = 340.00$$

$$ho_1 = 610.00$$

$$bi2_1 = 975400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.14776895$$

$$bo_2 = 192.00$$

$$ho_2 = 492.00$$

$$bi2_2 = 557856.00$$

$$psh_min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 1.22434$$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 777.0115

fy1 = 647.5096

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 777.0115

fy2 = 647.5096

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.194

fyv = 655.995

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lo_{u,min} = lb/d = 1.00

su_v = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fs_{yv} = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and y_v, sh_v,ft_v,fy_v, it is considered characteristic value fs_{yv} = fsv/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/d)^{2/3}), from 10.3.5, ASCE 41-17.

with fsv = (fs_{jacket}*As_{l,mid,jacket} + fs_{mid}*As_{l,mid,core})/As_{l,mid} = 655.995

with Es_v = (Es_{jacket}*As_{l,mid,jacket} + Es_{mid}*As_{l,mid,core})/As_{l,mid} = 200000.00

1 = As_{l,ten}/(b*d)*(fs₁/fc) = 0.07473725

2 = As_{l,com}/(b*d)*(fs₂/fc) = 0.07473725

v = As_{l,mid}/(b*d)*(fsv/fc) = 0.04621327

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = As_{l,ten}/(b*d)*(fs₁/fc) = 0.0896195

2 = As_{l,com}/(b*d)*(fs₂/fc) = 0.0896195

v = As_{l,mid}/(b*d)*(fsv/fc) = 0.05541561

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v < v_{s,c} - RHS eq.(4.5) is satisfied

--->

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu₂₊

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 0.00010364

Mu = 2.8782E+008

with full section properties:

b = 670.00

d = 357.00

d' = 43.00

v = 0.0002896

N = 2285.867

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00646173

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00646173

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14776895

ase1 = 0.14776895

bo_1 = 340.00

ho_1 = 610.00

bi₂_1 = 975400.00

ase2 = Max(ase1,ase2) = 0.14776895

bo_2 = 192.00

ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
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 = 647.5096

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
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 = 647.5096

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.194

$$f_{yv} = 655.995$$

$$s_{uv} = 0.032$$

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 γ_v , sh_v , ft_v , f_{y_v} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1 , ft_1 , f_{y_1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 655.995$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.07473725$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.07473725$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.04621327$$

and confined core properties:

$$b = 610.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.07072$$

$$c_c (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.0896195$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.0896195$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05541561$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.13515888$$

$$\mu_u = M_{Rc} (4.14) = 2.8782E+008$$

$$u = s_u (4.1) = 0.00010364$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_u

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010364$$

$$\mu_u = 2.8782E+008$$

with full section properties:

$$b = 670.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0002896$$

$$N = 2285.867$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00646173$$

$$w_e (5.4c) = 0.00548239$$

$$\text{ase} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

bi2_1 = 975400.00
ase2 = Max(ase1,ase2) = 0.14776895
bo_2 = 192.00
ho_2 = 492.00
bi2_2 = 557856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.22434

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008
ft1 = 777.0115
fy1 = 647.5096
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 777.0115
fy2 = 647.5096
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.194
fyv = 655.995
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 = 655.995

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07473725

2 = Asl,com/(b*d)*(fs2/fc) = 0.07473725

v = Asl,mid/(b*d)*(fsv/fc) = 0.04621327

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0896195

2 = Asl,com/(b*d)*(fs2/fc) = 0.0896195

v = Asl,mid/(b*d)*(fsv/fc) = 0.05541561

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368171.311

Calculation of Shear Strength at edge 1, Vr1 = 368171.311

Vr1 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: Vc = 182002.857

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.14925, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

pw = As/(bw*d) = 0.00331157

As (tension reinf.) = 709.9999

bw = 670.00

d = 320.00

Vu*d/Mu < 1 = 0.00

Mu = 2.3879272E-011

Vu = 1.2127266E-014

From (11.5.4.8), ACI 318-14: Vs1 + Vs2 = 186168.454

Vs1 = 186168.454 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 150.00$$

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 0.00 is calculated for jacket, with:

$$d_2 = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 300.00$$

Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 755657.47$$

Calculation of Shear Strength at edge 2, $V_{r2} = 368171.311$

$$V_{r2} = V_n \text{ ((22.5.1.1), ACI 318-14)}$$

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw + f*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 182002.857$

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 28.14925$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$p_w = A_s / (b_w * d) = 0.00331157$$

$$A_s \text{ (tension reinf.)} = 709.9999$$

$$b_w = 670.00$$

$$d = 320.00$$

$$V_u * d / M_u < 1 = 0.00$$

$$M_u = 1.2499023E-011$$

$$V_u = 1.2127266E-014$$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 186168.454$

Vs1 = 186168.454 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 150.00$$

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 0.00 is calculated for jacket, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 300.00$$

Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 755657.47$$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 670.00$
External Width, $W = 400.00$
Internal Height, $H = 500.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d >= 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 5.6070E+006$
Shear Force, $V_2 = -1.3148690E-014$
Shear Force, $V_3 = 4084.218$
Axial Force, $F = -7208.138$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 709.9999$
-Compression: $A_{sc,com} = 1266.062$
-Middle: $A_{sc,mid} = 402.1239$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten,jacket} = 402.1239$
-Compression: $A_{sc,com,jacket} = 804.2477$
-Middle: $A_{sc,mid,jacket} = 402.1239$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten,core} = 307.8761$
-Compression: $A_{sc,com,core} = 461.8141$
-Middle: $A_{sc,mid,core} = 0.00$
Mean Diameter of Tension Reinforcement, $DbL = 15.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = * u = 0.02651827$
 $u = y + p = 0.02651827$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00151827$ ((4.29), Biskinis Phd))
 $M_y = 2.5688E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1372.844
From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 7.7426E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 5.0866692E-006$
 with $f_y = 555.5556$
 $d = 627.00$
 $y = 0.18541981$
 $A = 0.00953771$
 $B = 0.00408912$
 with $pt = 0.00283094$
 $pc = 0.00504809$
 $pv = 0.00160336$
 $N = 7208.138$
 $b = 400.00$
 $" = 0.06858054$
 $y_{comp} = 1.9022082E-005$
 with $f_c = 28.14925$
 $E_c = 26999.444$
 $y = 0.18446162$
 $A = 0.00941708$
 $B = 0.0040338$
 with $E_s = 200000.00$

 Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-7: $p = 0.025$

with:

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.89177444$

- Transverse Reinforcement: C

- Stirrup Spacing $\leq d/3$

- Low ductility demand, $\lambda / y < 2$ (table 10-6, ASCE 41-17)

$= 5.9801381E-005$

- Stirrup Spacing $\leq d/2$

$d = d_{external} = 627.00$

$s = s_{external} = 150.00$

- Strength provided by hoops $V_s < 3/4 * \text{design Shear}$

$V_s = 371406.065$, already given in calculation of shear control ratio

design Shear = 4084.218

- (-)/ $bal = -0.26283917$

$= A_{st}/(b_w*d) = 0.00283094$

Tension Reinf Area: $A_{st} = 709.9999$

' = $A_{sc}/(b_w*d) = 0.00665146$

Compression Reinf Area: $A_{sc} = 1668.186$

From (B-1), ACI 318-11: $bal = 0.01453557$

$f_c = (f_{c_jacket} * \text{Area}_{jacket} + f_{c_core} * \text{Area}_{core}) / \text{section_area} = 28.14925$

$f_y = f_{y_jacket_bars} = 555.5556$

From 10.2.7.3, ACI 318-11: $\lambda = 1 = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000 / (87000 + f_y) = c_b/d_t = 0.003 / (0.003 + y) = 0.51923077$

$y = 0.00277778$

- $V / (b_w*d*f_c^{0.5}) = 0.03696333$, NOTE: units in lb & in

$b_w = 400.00$

End Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

beam B1, Floor 1

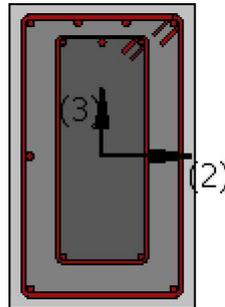
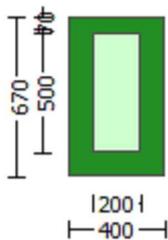
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 5.6070E+006$

Shear Force, $V_a = 4084.218$

EDGE -B-

Bending Moment, $M_b = 1.1663E+007$

Shear Force, $V_b = 15597.048$

BOTH EDGES

Axial Force, $F = -7208.138$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 709.9999$

-Compression: $As_c = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t, \text{ten}} = 709.9999$

-Compression: $As_{c, \text{com}} = 1266.062$

-Middle: $As_{c, \text{mid}} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_{L, \text{ten}} = 15.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 471754.435$
 V_n ((22.5.1.1), ACI 318-14) = 471754.435

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 164297.234$

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c, \text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_{c, \text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 21.64179$, but $f_c^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w \cdot d) = 0.00331157$

A_s (tension reinf.) = 709.9999

$b_w = 400.00$

$d = 536.00$

$V_u \cdot d / M_u < 1 = 0.39043026$

$M_u = 5.6070E+006$

$V_u = 4084.218$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 307457.201$

$V_{s1} = 280648.944$ is calculated for jacket, with:

$d = 536.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$V_{s2} = 26808.257$ is calculated for core, with:

$d = 400.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 300.00$

V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f < = 662579.716$

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

beam B1, Floor 1

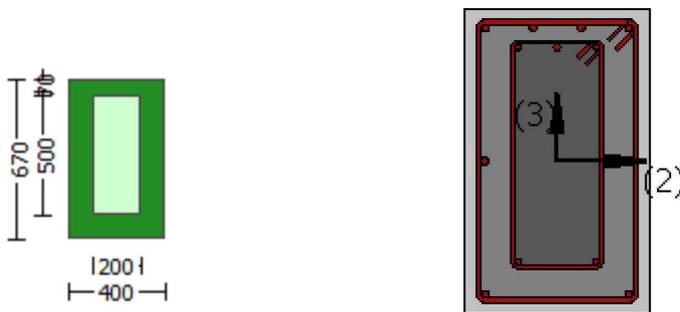
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.03245
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 9840.633$
EDGE -B-
Shear Force, $V_b = 9840.633$
BOTH EDGES
Axial Force, $F = -2285.867$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 709.9999$
-Compression: $A_{sc,com} = 1266.062$
-Middle: $A_{st,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.89177444$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 477716.403$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 7.0181E+008$
 $\mu_{u1+} = 4.0754E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 7.0181E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 7.0181E+008$
 $\mu_{u2+} = 4.0754E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 7.0181E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 9840.633$, is the shear force acting at edge 1 for the static loading combination
 $V_2 = 9840.633$, is the shear force acting at edge 2 for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 5.5992766E-005$
 $\mu_u = 4.0754E+008$

with full section properties:
 $b = 400.00$
 $d = 627.00$
 $d' = 43.00$
 $v = 0.00027619$
 $N = 2285.867$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00646173$$

$$w_e (5.4c) = 0.00548239$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 670.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_c = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$$fy_1 = 634.2183$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o / l_{o, \min} = l_b / l_d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1, \text{nominal}} = 0.08,$$

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1 / 1.2$, from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b / l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = (f_s, \text{jacket} * A_{s, \text{ten, jacket}} + f_s, \text{core} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 634.2183$$

$$\text{with } Es_1 = (E_s, \text{jacket} * A_{s, \text{ten, jacket}} + E_s, \text{core} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 772.5393$$

$$fy_2 = 643.7827$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 643.7827

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0544071

2 = Asl,com/(b*d)*(fs2/fc) = 0.09848107

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06722486

2 = Asl,com/(b*d)*(fs2/fc) = 0.1216822

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.08851292

Mu = MRc (4.14) = 4.0754E+008

u = su (4.1) = 5.5992766E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 5.9114336E-005

Mu = 7.0181E+008

with full section properties:

b = 400.00

d = 627.00

$d' = 43.00$
 $v = 0.00027619$
 $N = 2285.867$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$
 $w_e (5.4c) = 0.00548239$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$
 $ase1 = 0.14776895$
 $bo_1 = 340.00$
 $ho_1 = 610.00$
 $bi2_1 = 975400.00$
 $ase2 = Max(ase1, ase2) = 0.14776895$
 $bo_2 = 192.00$
 $ho_2 = 492.00$
 $bi2_2 = 557856.00$
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.22434$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00261799$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 670.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00062519$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 500.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00156298$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00025008$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 268000.00$
 $s1 = 150.00$
 $s2 = 300.00$
 $f_{ywe1} = 694.4444$
 $f_{ywe2} = 555.5556$
 $f_c = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00232446$
 $c = confinement\ factor = 1.03245$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 772.5393$
 $fy1 = 643.7827$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lo_{u,min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 643.7827$

with $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 761.0619$

$$fy2 = 634.2183$$

$$su2 = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 634.2183$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/d = 1.00$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06722486$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983$$

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

--->

$$su (4.8) = 0.13664457$$

$$Mu = MRc (4.15) = 7.0181E+008$$

$$u = su (4.1) = 5.9114336E-005$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 5.5992766E-005$$

Mu = 4.0754E+008

with full section properties:

b = 400.00

d = 627.00

d' = 43.00

v = 0.00027619

N = 2285.867

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00646173$

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$

ase1 = 0.14776895

bo_1 = 340.00

ho_1 = 610.00

bi2_1 = 975400.00

ase2 = $\text{Max}(ase1, ase2) = 0.14776895$

bo_2 = 192.00

ho_2 = 492.00

bi2_2 = 557856.00

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.22434$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00261799$

Ash1 = $A_{stir_1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 670.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00062519$

Ash2 = $A_{stir_2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 500.00

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00156298$

Ash1 = $A_{stir_1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 400.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00025008$

Ash2 = $A_{stir_2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: $cc = 0.00232446$

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 761.0619

fy1 = 634.2183

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 $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 634.2183$
 with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 772.5393$
 $fy_2 = 643.7827$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 643.7827$
 with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $fy_v = 694.4444$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.0544071$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09848107$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.03374084$
 and confined core properties:
 $b = 340.00$
 $d = 597.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.07072$
 $cc (5A.5, TBDY) = 0.00232446$
 $c = \text{confinement factor} = 1.03245$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.06722486$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.1216822$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04168983$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.08851292$
 $Mu = MRc (4.14) = 4.0754E+008$
 $u = su (4.1) = 5.5992766E-005$

 Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 5.9114336E-005$$

$$Mu = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00646173$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00646173$$

$$\phi_{we} \text{ (5.4c)} = 0.00548239$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 670.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy_1 = 643.7827$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o / l_{ou, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu_{1, \text{nominal}} = 0.08$,

For calculation of $es_{u1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_{y1} = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 643.7827$

with $Es_1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 761.0619$

$fy_2 = 634.2183$

$su_2 = 0.032$

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

$lo/lo_{ou,min} = lb/lb_{,min} = 1.00$

$su_2 = 0.4 \cdot es_{u2_nominal} ((5.5), TBDY) = 0.032$

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_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 634.2183$

with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo_{ou,min} = lb/ld = 1.00$

$su_v = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fs_{yv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot Asl_{mid,jacket} + f_{s,mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.4444$

with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09848107$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0544071$

$v = Asl_{mid} / (b \cdot d) \cdot (f_{sv} / fc) = 0.03374084$

and confined core properties:

$b = 340.00$

$d = 597.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.1216822$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.06722486$

$v = Asl_{mid} / (b \cdot d) \cdot (f_{sv} / fc) = 0.04168983$

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

--->

$su (4.8) = 0.13664457$

$Mu = MRc (4.15) = 7.0181E+008$

$u = su (4.1) = 5.9114336E-005$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 535691.969$

Calculation of Shear Strength at edge 1, $V_{r1} = 535691.969$
 $V_{r1} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $p_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u \cdot d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
 $V_u = 9840.633$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
 $d = 536.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 29786.953$ is calculated for jacket, with:
 $d_2 = 400.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 300.00$
 V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

Calculation of Shear Strength at edge 2, $V_{r2} = 535691.969$
 $V_{r2} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $p_w = A_s / (b_w \cdot d) = 0.00331157$
 A_s (tension reinf.) = 709.9999
 $b_w = 400.00$
 $d = 536.00$
 $V_u \cdot d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
 $V_u = 9840.633$
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
 $d = 536.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 150.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 29786.953$ is calculated for jacket, with:
 $d = 400.00$
 $A_v = 100530.965$
 $f_y = 444.4444$

s = 300.00

Vs2 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 755657.47

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 694.4444

Existing Column

Existing material: Steel Strength, fs = 1.25*fsm = 555.5556

#####

External Height, H = 670.00

External Width, W = 400.00

Internal Height, H = 500.00

Internal Width, W = 200.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.03245

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/lo,min>= 1)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = 1.2127266E-014

EDGE -B-

Shear Force, Vb = -1.2127266E-014

BOTH EDGES

Axial Force, F = -2285.867

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 709.9999

-Compression: $Asl,c = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $Asl,t = 911.0619$
-Compression: $Asl,c = 911.0619$
-Middle: $Asl,m = 556.0619$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.52117341$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 191881.096$
with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 2.8782E+008$

$\mu_{1+} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{1-} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 2.8782E+008$

$\mu_{2+} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$\mu_{2-} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 1.2127266E-014$, is the shear force acting at edge 1 for the the static loading combination

$V_2 = -1.2127266E-014$, is the shear force acting at edge 2 for the the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00010364$

$\mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \max(\phi_u, \phi_c) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00646173$

w_e (5.4c) = 0.00548239

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.14776895$

$a_{se1} = 0.14776895$

$b_{o,1} = 340.00$

$h_{o,1} = 610.00$

$b_{i,1} = 975400.00$

$a_{se2} = \max(a_{se1}, a_{se2}) = 0.14776895$

$b_{o,2} = 192.00$

$h_{o,2} = 492.00$

$b_{i,2} = 557856.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.22434$

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 2.16538$

p_{s1} (external) = $(A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00261799$

$A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$

No stirups, $n_{s,1} = 2.00$

$h_1 = 670.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00062519$

Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00
s1 = 150.00
s2 = 300.00

fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y1 = 0.0025
sh1 = 0.008

ft1 = 777.0115
fy1 = 647.5096

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 = 647.5096

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008

ft2 = 777.0115
fy2 = 647.5096

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 = 647.5096

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008

ftv = 787.194
fyv = 655.995

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 655.995$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07473725$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07473725$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.0896195$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.0896195$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.13515888$

$Mu = MRc (4.14) = 2.8782E+008$

$u = su (4.1) = 0.00010364$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010364$

$Mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00646173$

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.14776895$

$ase_1 = 0.14776895$

$bo_1 = 340.00$

$ho_1 = 610.00$

$bi_2_1 = 975400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.14776895$

$bo_2 = 192.00$

$ho_2 = 492.00$

$bi_2_2 = 557856.00$

$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 1.22434$

$psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 2.16538$

ps_1 (external) = $(Ash_1 \cdot h_1 / s_1) / A_{sec} = 0.00261799$

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirups, ns₁ = 2.00
h₁ = 670.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00062519
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 500.00

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 1.22434
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00156298
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00025008
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

Asec = 268000.00
s₁ = 150.00
s₂ = 300.00
fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y₁ = 0.0025
sh₁ = 0.008
ft₁ = 777.0115
fy₁ = 647.5096
su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 1.00

su₁ = 0.4*esu₁_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu₁_nominal = 0.08,

For calculation of esu₁_nominal and y₁, sh₁,ft₁,fy₁, it is considered
characteristic value fsy₁ = fs₁/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₁ = (fs_{jacket}*As_{l,ten,jacket} + fs_{core}*As_{l,ten,core})/As_{l,ten} = 647.5096

with Es₁ = (Es_{jacket}*As_{l,ten,jacket} + Es_{core}*As_{l,ten,core})/As_{l,ten} = 200000.00

y₂ = 0.0025
sh₂ = 0.008
ft₂ = 777.0115
fy₂ = 647.5096
su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_{b,min} = 1.00

su₂ = 0.4*esu₂_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu₂_nominal = 0.08,

For calculation of esu₂_nominal and y₂, sh₂,ft₂,fy₂, it is considered
characteristic value fsy₂ = fs₂/1.2, from table 5.1, TBDY.

y₂, sh₂,ft₂,fy₂, are also multiplied by Min(1,1.25*(lb/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = (fs_{jacket}*As_{l,com,jacket} + fs_{core}*As_{l,com,core})/As_{l,com} = 647.5096

with Es₂ = (Es_{jacket}*As_{l,com,jacket} + Es_{core}*As_{l,com,core})/As_{l,com} = 200000.00

y_v = 0.0025
sh_v = 0.008
ft_v = 787.194
fy_v = 655.995
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $e_{suv_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 655.995$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07473725$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07473725$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.0896195$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.0896195$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

su (4.9) = 0.13515888

$Mu = MR_c$ (4.14) = 2.8782E+008

$u = su$ (4.1) = 0.00010364

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:

$u = 0.00010364$

$Mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00646173$

w_e (5.4c) = 0.00548239

ase ((5.4d), TBDY) = $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.14776895$

$ase_1 = 0.14776895$

$bo_1 = 340.00$

$ho_1 = 610.00$

$bi_{2,1} = 975400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.14776895$

$bo_2 = 192.00$

$ho_2 = 492.00$

$bi_{2,2} = 557856.00$

$psh_{,min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 1.22434$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 777.0115

fy1 = 647.5096

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 777.0115

fy2 = 647.5096

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.194

fyv = 655.995

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.

with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 655.995

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07473725

2 = Asl,com/(b*d)*(fs2/fc) = 0.07473725

v = Asl,mid/(b*d)*(fsv/fc) = 0.04621327

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0896195

2 = Asl,com/(b*d)*(fs2/fc) = 0.0896195

v = Asl,mid/(b*d)*(fsv/fc) = 0.05541561

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 0.00010364

Mu = 2.8782E+008

with full section properties:

b = 670.00

d = 357.00

d' = 43.00

v = 0.0002896

N = 2285.867

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00646173

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00646173

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14776895

ase1 = 0.14776895

bo_1 = 340.00

ho_1 = 610.00

bi2_1 = 975400.00

ase2 = Max(ase1,ase2) = 0.14776895

bo_2 = 192.00

ho_2 = 492.00

$$bi2_2 = 557856.00$$
$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.22434$$

$$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.16538$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00261799$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 670.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00062519$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 500.00$$

$$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.22434$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00156298$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 400.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00025008$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 200.00$$

$$Asec = 268000.00$$

$$s1 = 150.00$$

$$s2 = 300.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 777.0115$$

$$fy1 = 647.5096$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/l_d = 1.00$$

$$su1 = 0.4*esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 777.0115$$

$$fy2 = 647.5096$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/l_b,min = 1.00$$

$$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.194$$

$$fyv = 655.995$$

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 = 655.995

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07473725

2 = Asl,com/(b*d)*(fs2/fc) = 0.07473725

v = Asl,mid/(b*d)*(fsv/fc) = 0.04621327

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0896195

2 = Asl,com/(b*d)*(fs2/fc) = 0.0896195

v = Asl,mid/(b*d)*(fsv/fc) = 0.05541561

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368171.311

Calculation of Shear Strength at edge 1, Vr1 = 368171.311

Vr1 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: Vc = 182002.857

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.14925, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

pw = As/(bw*d) = 0.00331157

As (tension reinf.) = 709.9999

bw = 670.00

d = 320.00

Vu*d/Mu < 1 = 0.00

Mu = 2.3879272E-011

Vu = 1.2127266E-014

From (11.5.4.8), ACI 318-14: Vs1 + Vs2 = 186168.454

Vs1 = 186168.454 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 150.00

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 0.00 is calculated for jacket, with:

d2 = 160.00

Av = 100530.965

fy = 444.4444

s = 300.00

Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

Calculation of Shear Strength at edge 2, Vr2 = 368171.311

Vr2 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: Vc = 182002.857

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 28.14925$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

pw = $As / (bw * d) = 0.00331157$

As (tension reinf.) = 709.9999

bw = 670.00

d = 320.00

$V_u * d / Mu < 1 = 0.00$

Mu = 1.2499023E-011

Vu = 1.2127266E-014

From (11.5.4.8), ACI 318-14: Vs1 + Vs2 = 186168.454

Vs1 = 186168.454 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 150.00

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 0.00 is calculated for jacket, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 300.00

Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 670.00$
 External Width, $W = 400.00$
 Internal Height, $H = 500.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d >= 1$)
 No FRP Wrapping

 Stepwise Properties

Bending Moment, $M = -2.9386296E-011$
 Shear Force, $V_2 = -1.3148690E-014$
 Shear Force, $V_3 = 4084.218$
 Axial Force, $F = -7208.138$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 709.9999$
 -Compression: $A_{sc} = 1668.186$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 911.0619$
 -Compression: $A_{st,com} = 911.0619$
 -Middle: $A_{st,mid} = 556.0619$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,jacket} = 603.1858$
 -Compression: $A_{st,com,jacket} = 603.1858$
 -Middle: $A_{st,mid,jacket} = 402.1239$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,core} = 307.8761$
 -Compression: $A_{st,com,core} = 307.8761$
 -Middle: $A_{st,mid,core} = 153.938$
 Mean Diameter of Tension Reinforcement, $DbL = 15.20$

 Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = \phi_u = 0.02370676$
 $\phi_u = \phi_y + \phi_p = 0.02370676$

 - Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00370676$ ((4.29), Biskinis Phd))
 $M_y = 1.8686E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 2.5206E+013$

 Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \text{Min}(\phi_{y,ten}, \phi_{y,com})$
 $\phi_{y,ten} = 9.3782340E-006$
 with $f_y = 555.5556$
 $d = 357.00$
 $\phi_y = 0.22402881$

A = 0.01000066
 B = 0.00562812
 with pt = 0.00380895
 pc = 0.00380895
 pv = 0.00232477
 N = 7208.138
 b = 670.00
 " = 0.12044818
 y_comp = 2.7599233E-005
 with fc = 28.14925
 Ec = 26999.444
 y = 0.22328852
 A = 0.00987417
 B = 0.00557012
 with Es = 200000.00

 Calculation of ratio lb/d

 Adequate Lap Length: lb/d >= 1

 - Calculation of p -

 From table 10-7: p = 0.02

with:

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.52117341$

- Transverse Reinforcement: NC

- Stirrup Spacing > d/3

- Low ductility demand, $\lambda < 2$ (table 10-6, ASCE 41-17)

= 4.4590469E-022

- Stirrup Spacing <= d/2

d = d_external = 357.00

s = s_external = 150.00

- Strength provided by hoops $V_s < 3/4$ *design Shear

$V_s = 209998.016$, already given in calculation of shear control ratio

design Shear = 1.3148690E-014

- ($\lambda - 1$)/ bal = -0.27559707

= $A_{st}/(b_w*d) = 0.00296835$

Tension Reinf Area: $A_{st} = 709.9999$

' = $A_{sc}/(b_w*d) = 0.00697431$

Compression Reinf Area: $A_{sc} = 1668.186$

From (B-1), ACI 318-11: bal = 0.01453557

$f_c = (f_{c_jacket}*Area_jacket + f_{c_core}*Area_core)/section_area = 28.14925$

$f_y = f_{y_jacket_bars} = 555.5556$

From 10.2.7.3, ACI 318-11: $\lambda = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \lambda) = 0.51923077$

$\lambda = 0.00277778$

- $V/(b_w*d*f_c^{0.5}) = 1.2477548E-019$, NOTE: units in lb & in

$b_w = 670.00$

 End Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

beam B1, Floor 1

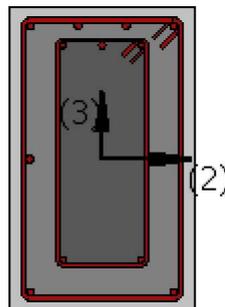
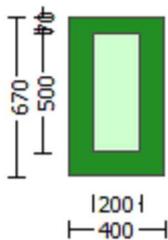
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -2.9386296E-011$

Shear Force, $V_a = -1.3148690E-014$

EDGE -B-

Bending Moment, $M_b = -1.0292494E-011$

Shear Force, $V_b = 1.3148690E-014$

BOTH EDGES

Axial Force, $F = -7208.138$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 709.9999$

-Compression: $As_c = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t, \text{ten}} = 911.0619$

-Compression: $As_{c, \text{com}} = 911.0619$

-Middle: $As_{c, \text{mid}} = 556.0619$

Mean Diameter of Tension Reinforcement, $Db_{L, \text{ten}} = 15.20$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 327136.349$
 V_n ((22.5.1.1), ACI 318-14) = 327136.349

NOTE: In expression (22.5.1.1) ' V_w ' is replaced by ' $V_w + f_v V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 159584.741$

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c, \text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_{c, \text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 21.64179$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w \cdot d) = 0.00331157$

A_s (tension reinf.) = 709.9999

$b_w = 670.00$

$d = 320.00$

$V_u \cdot d / M_u < 1 = 0.00$

$M_u = 1.0292494E-011$

$V_u = 1.3148690E-014$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 167551.608$

$V_{s1} = 167551.608$ is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)

$V_{s2} = 0.00$ is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 300.00$

V_{s2} is considered 0 ($s > d$, according to ASCE 41-17, 10.3.4)

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 662579.716$

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 14

beam B1, Floor 1

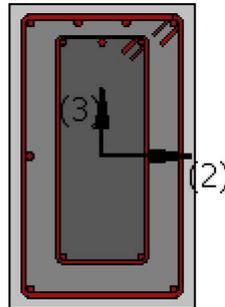
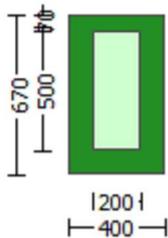
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.03245
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 9840.633$
EDGE -B-
Shear Force, $V_b = 9840.633$
BOTH EDGES
Axial Force, $F = -2285.867$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 709.9999$
-Compression: $A_{sc} = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 709.9999$
-Compression: $A_{sc,com} = 1266.062$
-Middle: $A_{st,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.89177444$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 477716.403$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 7.0181E+008$
 $\mu_{u1+} = 4.0754E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 7.0181E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 7.0181E+008$
 $\mu_{u2+} = 4.0754E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 7.0181E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 9840.633$, is the shear force acting at edge 1 for the static loading combination
 $V_2 = 9840.633$, is the shear force acting at edge 2 for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 5.5992766E-005$
 $\mu_u = 4.0754E+008$

with full section properties:

$b = 400.00$
 $d = 627.00$
 $d' = 43.00$
 $v = 0.00027619$
 $N = 2285.867$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00646173$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00646173$$

$$w_e (5.4c) = 0.00548239$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 670.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_c = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 761.0619$$

$$fy_1 = 634.2183$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o / l_{o, \min} = l_b / l_d = 1.00$$

$$su_1 = 0.4 * es_{u1, \text{nominal}} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } es_{u1, \text{nominal}} = 0.08,$$

For calculation of $es_{u1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fs_{y1} = fs_1 / 1.2$, from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b / l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 634.2183$$

$$\text{with } Es_1 = (E_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + E_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 772.5393$$

$$fy_2 = 643.7827$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 643.7827

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.3333

fyv = 694.4444

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0544071

2 = Asl,com/(b*d)*(fs2/fc) = 0.09848107

v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084

and confined core properties:

b = 340.00

d = 597.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06722486

2 = Asl,com/(b*d)*(fs2/fc) = 0.1216822

v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.08851292

Mu = MRc (4.14) = 4.0754E+008

u = su (4.1) = 5.5992766E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 5.9114336E-005

Mu = 7.0181E+008

with full section properties:

b = 400.00

d = 627.00

$d' = 43.00$
 $v = 0.00027619$
 $N = 2285.867$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00646173$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00646173$
 $w_e (5.4c) = 0.00548239$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$
 $ase1 = 0.14776895$
 $bo_1 = 340.00$
 $ho_1 = 610.00$
 $bi2_1 = 975400.00$
 $ase2 = Max(ase1, ase2) = 0.14776895$
 $bo_2 = 192.00$
 $ho_2 = 492.00$
 $bi2_2 = 557856.00$
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.22434$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00261799$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 670.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00062519$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 500.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00156298$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00025008$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 268000.00$
 $s1 = 150.00$
 $s2 = 300.00$
 $f_{ywe1} = 694.4444$
 $f_{ywe2} = 555.5556$
 $f_c = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00232446$
 $c = confinement\ factor = 1.03245$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 772.5393$
 $fy1 = 643.7827$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lo_{u,min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 643.7827$

with $Es1 = (Es, jacket * A_{sl, ten, jacket} + Es, core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 761.0619$

$$fy2 = 634.2183$$

$$su2 = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 634.2183$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.3333$$

$$fyv = 694.4444$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.4444$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09848107$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.0544071$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03374084$$

and confined core properties:

$$b = 340.00$$

$$d = 597.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.07072$$

$$cc (5A.5, TBDY) = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.1216822$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06722486$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04168983$$

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

--->

$$su (4.8) = 0.13664457$$

$$Mu = MRc (4.15) = 7.0181E+008$$

$$u = su (4.1) = 5.9114336E-005$$

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:

$$u = 5.5992766E-005$$

Mu = 4.0754E+008

with full section properties:

b = 400.00

d = 627.00

d' = 43.00

v = 0.00027619

N = 2285.867

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00646173$

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.14776895$

ase1 = 0.14776895

bo_1 = 340.00

ho_1 = 610.00

bi2_1 = 975400.00

ase2 = $\text{Max}(ase1, ase2) = 0.14776895$

bo_2 = 192.00

ho_2 = 492.00

bi2_2 = 557856.00

$psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.22434$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.16538$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00261799$

Ash1 = $A_{stir,1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 670.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00062519$

Ash2 = $A_{stir,2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 500.00

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.22434$

ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00156298$

Ash1 = $A_{stir,1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 400.00

ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00025008$

Ash2 = $A_{stir,2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: $cc = 0.00232446$

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 761.0619

fy1 = 634.2183

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 $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 634.2183$
 with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 772.5393$
 $fy_2 = 643.7827$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 643.7827$
 with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.3333$
 $fy_v = 694.4444$
 $su_v = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_d = 1.00$
 $su_v = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.0544071$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09848107$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.03374084$
 and confined core properties:
 $b = 340.00$
 $d = 597.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 34.07072$
 $cc (5A.5, TBDY) = 0.00232446$
 $c = \text{confinement factor} = 1.03245$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.06722486$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.1216822$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04168983$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.08851292$
 $Mu = MRc (4.14) = 4.0754E+008$
 $u = su (4.1) = 5.5992766E-005$

 Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

 Calculation of Mu_2 -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 5.9114336E-005$$

$$Mu = 7.0181E+008$$

with full section properties:

$$b = 400.00$$

$$d = 627.00$$

$$d' = 43.00$$

$$v = 0.00027619$$

$$N = 2285.867$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00646173$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00646173$$

$$w_e(5.4c) = 0.00548239$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.14776895$$

$$a_{se1} = 0.14776895$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 610.00$$

$$b_{i2_1} = 975400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.14776895$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 492.00$$

$$b_{i2_2} = 557856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.22434$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.16538$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00261799$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 670.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00062519$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 500.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.22434$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00156298$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00025008$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 268000.00$$

$$s_1 = 150.00$$

$$s_2 = 300.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 772.5393$$

$$fy_1 = 643.7827$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o / l_{o, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}}((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{1, \text{nominal}} = 0.08$,

For calculation of $es_{u1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_{y1} = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (fs_{jacket} \cdot A_{s,ten,jacket} + fs_{core} \cdot A_{s,ten,core}) / A_{s,ten} = 643.7827$

with $Es_1 = (Es_{jacket} \cdot A_{s,ten,jacket} + Es_{core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 761.0619$

$fy_2 = 634.2183$

$su_2 = 0.032$

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

$lo/lo_{ou,min} = lb/lb_{,min} = 1.00$

$su_2 = 0.4 \cdot es_{u2_nominal} ((5.5), TBDY) = 0.032$

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_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 634.2183$

with $Es_2 = (Es_{jacket} \cdot A_{s,com,jacket} + Es_{core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.3333$

$fy_v = 694.4444$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo_{ou,min} = lb/ld = 1.00$

$su_v = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fs_{yv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.4444$

with $Es_v = (Es_{jacket} \cdot A_{s,mid,jacket} + Es_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09848107$

$2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0544071$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / fc) = 0.03374084$

and confined core properties:

$b = 340.00$

$d = 597.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.1216822$

$2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.06722486$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / fc) = 0.04168983$

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

--->

$su (4.8) = 0.13664457$

$Mu = MRc (4.15) = 7.0181E+008$

$u = su (4.1) = 5.9114336E-005$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 535691.969$

Calculation of Shear Strength at edge 1, $V_{r1} = 535691.969$
 $V_{r1} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $p_w = A_s / (b_w \cdot d) = 0.00331157$
As (tension reinf.) = 709.9999
bw = 400.00
d = 536.00
 $V_u \cdot d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
Vu = 9840.633
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
d = 536.00
Av = 157079.633
fy = 555.5556
s = 150.00
Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 29786.953$ is calculated for jacket, with:
d2 = 400.00
Av = 100530.965
fy = 444.4444
s = 300.00
Vs2 has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.50$
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

Calculation of Shear Strength at edge 2, $V_{r2} = 535691.969$
 $V_{r2} = V_n$ ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 194072.856$
= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 28.14925$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $p_w = A_s / (b_w \cdot d) = 0.00331157$
As (tension reinf.) = 709.9999
bw = 400.00
d = 536.00
 $V_u \cdot d / \mu < 1 = 1.00$
 $\mu = 1.1086E+006$
Vu = 9840.633
From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 341619.112$
 $V_{s1} = 311832.16$ is calculated for jacket, with:
d = 536.00
Av = 157079.633
fy = 555.5556
s = 150.00
Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 29786.953$ is calculated for jacket, with:
d = 400.00
Av = 100530.965
fy = 444.4444

s = 300.00

Vs2 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 755657.47

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 694.4444

Existing Column

Existing material: Steel Strength, fs = 1.25*fsm = 555.5556

#####

External Height, H = 670.00

External Width, W = 400.00

Internal Height, H = 500.00

Internal Width, W = 200.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.03245

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/lou,min>=1)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = 1.2127266E-014

EDGE -B-

Shear Force, Vb = -1.2127266E-014

BOTH EDGES

Axial Force, F = -2285.867

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 709.9999

-Compression: $Asl,c = 1668.186$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $Asl,t = 911.0619$
-Compression: $Asl,c = 911.0619$
-Middle: $Asl,m = 556.0619$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.52117341$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 191881.096$
with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 2.8782E+008$

$\mu_{1+} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{1-} = 2.8782E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 2.8782E+008$

$\mu_{2+} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$\mu_{2-} = 2.8782E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 1.2127266E-014$, is the shear force acting at edge 1 for the the static loading combination

$V_2 = -1.2127266E-014$, is the shear force acting at edge 2 for the the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00010364$

$\mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \max(\phi_u, \phi_c) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00646173$

w_e (5.4c) = 0.00548239

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.14776895$

$a_{se1} = 0.14776895$

$b_{o1} = 340.00$

$h_{o1} = 610.00$

$b_{i21} = 975400.00$

$a_{se2} = \max(a_{se1}, a_{se2}) = 0.14776895$

$b_{o2} = 192.00$

$h_{o2} = 492.00$

$b_{i22} = 557856.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.22434$

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 2.16538$

p_{s1} (external) = $(A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00261799$

$A_{sh1} = A_{stir,1} \cdot n_{s1} = 157.0796$

No stirups, $n_{s1} = 2.00$

$h_1 = 670.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00062519$

Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 777.0115

fy1 = 647.5096

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 777.0115

fy2 = 647.5096

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 = 647.5096

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.194

fyv = 655.995

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 655.995$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07473725$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07473725$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.07072$

$cc (5A.5, TBDY) = 0.00232446$

$c = \text{confinement factor} = 1.03245$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.0896195$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.0896195$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.13515888$

$Mu = MRc (4.14) = 2.8782E+008$

$u = su (4.1) = 0.00010364$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010364$

$Mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$f_c = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00646173$

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.14776895$

$ase_1 = 0.14776895$

$bo_1 = 340.00$

$ho_1 = 610.00$

$bi_2_1 = 975400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.14776895$

$bo_2 = 192.00$

$ho_2 = 492.00$

$bi_2_2 = 557856.00$

$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 1.22434$

 $psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 2.16538$

ps_1 (external) = $(Ash_1 \cdot h_1 / s_1) / A_{sec} = 0.00261799$

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirups, ns₁ = 2.00
h₁ = 670.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00062519
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 500.00

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 1.22434
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00156298
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 400.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00025008
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 200.00

Asec = 268000.00
s₁ = 150.00
s₂ = 300.00
fywe₁ = 694.4444
fywe₂ = 555.5556
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00232446
c = confinement factor = 1.03245

y₁ = 0.0025
sh₁ = 0.008
ft₁ = 777.0115
fy₁ = 647.5096
su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 1.00

su₁ = 0.4*esu₁_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu₁_nominal = 0.08,

For calculation of esu₁_nominal and y₁, sh₁,ft₁,fy₁, it is considered
characteristic value fsy₁ = fs₁/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₁ = (fs_{jacket}*As_{l,ten,jacket} + fs_{core}*As_{l,ten,core})/As_{l,ten} = 647.5096

with Es₁ = (Es_{jacket}*As_{l,ten,jacket} + Es_{core}*As_{l,ten,core})/As_{l,ten} = 200000.00

y₂ = 0.0025
sh₂ = 0.008
ft₂ = 777.0115
fy₂ = 647.5096
su₂ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_{b,min} = 1.00

su₂ = 0.4*esu₂_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu₂_nominal = 0.08,

For calculation of esu₂_nominal and y₂, sh₂,ft₂,fy₂, it is considered
characteristic value fsy₂ = fs₂/1.2, from table 5.1, TBDY.

y₂, sh₂,ft₂,fy₂, are also multiplied by Min(1,1.25*(lb/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = (fs_{jacket}*As_{l,com,jacket} + fs_{core}*As_{l,com,core})/As_{l,com} = 647.5096

with Es₂ = (Es_{jacket}*As_{l,com,jacket} + Es_{core}*As_{l,com,core})/As_{l,com} = 200000.00

y_v = 0.0025
sh_v = 0.008
ft_v = 787.194
fy_v = 655.995
su_v = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 1.00

su_v = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv,ftv,fyv , it is considered
characteristic value $fsv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 655.995$

with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$

$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07473725$

$2 = Asl,com/(b*d)*(fs2/fc) = 0.07473725$

$v = Asl,mid/(b*d)*(fsv/fc) = 0.04621327$

and confined core properties:

$b = 610.00$

$d = 327.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

$c =$ confinement factor = 1.03245

$1 = Asl,ten/(b*d)*(fs1/fc) = 0.0896195$

$2 = Asl,com/(b*d)*(fs2/fc) = 0.0896195$

$v = Asl,mid/(b*d)*(fsv/fc) = 0.05541561$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

$v < vs,c$ - RHS eq.(4.5) is satisfied

---->

su (4.9) = 0.13515888

$Mu = MRc$ (4.14) = 2.8782E+008

$u = su$ (4.1) = 0.00010364

Calculation of ratio lb/l_d

Adequate Lap Length: $lb/l_d \geq 1$

Calculation of Mu_{2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010364$

$Mu = 2.8782E+008$

with full section properties:

$b = 670.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0002896$

$N = 2285.867$

$fc = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00646173$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00646173$

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = $(ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.14776895$

$ase1 = 0.14776895$

$bo_1 = 340.00$

$ho_1 = 610.00$

$bi2_1 = 975400.00$

$ase2 = Max(ase1, ase2) = 0.14776895$

$bo_2 = 192.00$

$ho_2 = 492.00$

$bi2_2 = 557856.00$

$psh,min*Fywe = Min(psh,x*Fywe, psh,y*Fywe) = 1.22434$

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00261799
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 670.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00062519
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 500.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00156298
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00025008
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 268000.00

s1 = 150.00

s2 = 300.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00232446

c = confinement factor = 1.03245

y1 = 0.0025

sh1 = 0.008

ft1 = 777.0115

fy1 = 647.5096

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 777.0115

fy2 = 647.5096

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.194

fyv = 655.995

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 = 655.995

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07473725

2 = Asl,com/(b*d)*(fs2/fc) = 0.07473725

v = Asl,mid/(b*d)*(fsv/fc) = 0.04621327

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0896195

2 = Asl,com/(b*d)*(fs2/fc) = 0.0896195

v = Asl,mid/(b*d)*(fsv/fc) = 0.05541561

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

v < vs,c - RHS eq.(4.5) is satisfied

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 0.00010364

Mu = 2.8782E+008

with full section properties:

b = 670.00

d = 357.00

d' = 43.00

v = 0.0002896

N = 2285.867

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00646173

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00646173

we (5.4c) = 0.00548239

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14776895

ase1 = 0.14776895

bo_1 = 340.00

ho_1 = 610.00

bi2_1 = 975400.00

ase2 = Max(ase1,ase2) = 0.14776895

bo_2 = 192.00

ho_2 = 492.00

$$bi2_2 = 557856.00$$
$$psh,min*Fywe = \text{Min}(psh,x*Fywe , psh,y*Fywe) = 1.22434$$

$$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.16538$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00261799$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 670.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00062519$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 500.00$$

$$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.22434$$
$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00156298$$
$$Ash1 = Astir_1*ns_1 = 157.0796$$
$$\text{No stirups, } ns_1 = 2.00$$
$$h1 = 400.00$$
$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00025008$$
$$Ash2 = Astir_2*ns_2 = 100.531$$
$$\text{No stirups, } ns_2 = 2.00$$
$$h2 = 200.00$$

$$Asec = 268000.00$$

$$s1 = 150.00$$

$$s2 = 300.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00232446$$

$$c = \text{confinement factor} = 1.03245$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 777.0115$$

$$fy1 = 647.5096$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/l_d = 1.00$$

$$su1 = 0.4*esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1,1.25*(lb/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 647.5096$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 777.0115$$

$$fy2 = 647.5096$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/l_b,min = 1.00$$

$$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1,1.25*(lb/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 647.5096$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.194$$

$$fyv = 655.995$$

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 = 655.995

with Esv = (Esjacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07473725

2 = Asl,com/(b*d)*(fs2/fc) = 0.07473725

v = Asl,mid/(b*d)*(fsv/fc) = 0.04621327

and confined core properties:

b = 610.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.07072

cc (5A.5, TBDY) = 0.00232446

c = confinement factor = 1.03245

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0896195

2 = Asl,com/(b*d)*(fs2/fc) = 0.0896195

v = Asl,mid/(b*d)*(fsv/fc) = 0.05541561

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.9) = 0.13515888

Mu = MRc (4.14) = 2.8782E+008

u = su (4.1) = 0.00010364

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368171.311

Calculation of Shear Strength at edge 1, Vr1 = 368171.311

Vr1 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: Vc = 182002.857

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.14925, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

pw = As/(bw*d) = 0.00331157

As (tension reinf.) = 709.9999

bw = 670.00

d = 320.00

Vu*d/Mu < 1 = 0.00

Mu = 2.3879272E-011

Vu = 1.2127266E-014

From (11.5.4.8), ACI 318-14: Vs1 + Vs2 = 186168.454

Vs1 = 186168.454 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 150.00

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 0.00 is calculated for jacket, with:

d2 = 160.00

Av = 100530.965

fy = 444.4444

s = 300.00

Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

Calculation of Shear Strength at edge 2, Vr2 = 368171.311

Vr2 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: Vc = 182002.857

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.14925$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

pw = As/(bw*d) = 0.00331157

As (tension reinf.) = 709.9999

bw = 670.00

d = 320.00

Vu*d/Mu < 1 = 0.00

Mu = 1.2499023E-011

Vu = 1.2127266E-014

From (11.5.4.8), ACI 318-14: Vs1 + Vs2 = 186168.454

Vs1 = 186168.454 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 150.00

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 0.00 is calculated for jacket, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 300.00

Vs2 is considered 0 ($s > d$, according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 755657.47$

End Of Calculation of Shear Capacity ratio for element: beam JB1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjars

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 670.00$
 External Width, $W = 400.00$
 Internal Height, $H = 500.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d >= 1$)
 No FRP Wrapping

 Stepwise Properties

Bending Moment, $M = 1.1663E+007$
 Shear Force, $V_2 = 1.3148690E-014$
 Shear Force, $V_3 = 15597.048$
 Axial Force, $F = -7208.138$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 709.9999$
 -Compression: $A_{sc} = 1668.186$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 709.9999$
 -Compression: $A_{sc,com} = 1266.062$
 -Middle: $A_{sc,mid} = 402.1239$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,jacket} = 402.1239$
 -Compression: $A_{sc,com,jacket} = 804.2477$
 -Middle: $A_{sc,mid,jacket} = 402.1239$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,core} = 307.8761$
 -Compression: $A_{sc,com,core} = 461.8141$
 -Middle: $A_{sc,mid,core} = 0.00$
 Mean Diameter of Tension Reinforcement, $DbL = 15.00$

 Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = \phi_u = 0.02582696$
 $\phi_u = \phi_y + \phi_p = 0.02582696$

 - Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00082696$ ((4.29), Biskinis Phd))
 $M_y = 2.5688E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 747.7501
 From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 7.7426E+013$

 Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \text{Min}(\phi_{y,ten}, \phi_{y,com})$
 $\phi_{y,ten} = 5.0866692E-006$
 with $f_y = 555.5556$
 $d = 627.00$
 $\phi_y = 0.18541981$

A = 0.00953771
 B = 0.00408912
 with pt = 0.00283094
 pc = 0.00504809
 pv = 0.00160336
 N = 7208.138
 b = 400.00
 " = 0.06858054
 y_comp = 1.9022082E-005
 with fc = 28.14925
 Ec = 26999.444
 y = 0.18446162
 A = 0.00941708
 B = 0.0040338
 with Es = 200000.00

 Calculation of ratio lb/d

 Adequate Lap Length: lb/d >= 1

 - Calculation of p -

 From table 10-7: p = 0.025

with:

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.89177444$

- Transverse Reinforcement: C

- Stirrup Spacing $\leq d/3$

- Low ductility demand, $\lambda / y < 2$ (table 10-6, ASCE 41-17)

= 4.7666866E-006

- Stirrup Spacing $\leq d/2$

d = d_external = 627.00

s = s_external = 150.00

- Strength provided by hoops $V_s < 3/4$ *design Shear

$V_s = 371406.065$, already given in calculation of shear control ratio

design Shear = 15597.048

- (- ')/ bal = -0.26283917

= $A_{st}/(b_w*d) = 0.00283094$

Tension Reinf Area: $A_{st} = 709.9999$

' = $A_{sc}/(b_w*d) = 0.00665146$

Compression Reinf Area: $A_{sc} = 1668.186$

From (B-1), ACI 318-11: bal = 0.01453557

$f_c = (f_{c_jacket}*Area_jacket + f_{c_core}*Area_core)/section_area = 28.14925$

$f_y = f_{y_jacket_bars} = 555.5556$

From 10.2.7.3, ACI 318-11: $\lambda = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + y) = 0.51923077$

y = 0.00277778

- $V/(b_w*d*f_c^{0.5}) = 0.14115773$, NOTE: units in lb & in

$b_w = 400.00$

 End Of Calculation of Chord Rotation Capacity for element: beam JB1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

beam B1, Floor 1

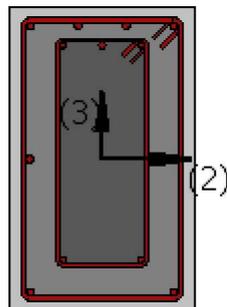
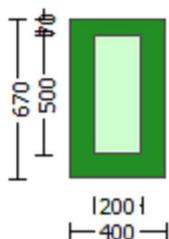
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjars

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 670.00$

External Width, $W = 400.00$

Internal Height, $H = 500.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 5.6070E+006$

Shear Force, $V_a = 4084.218$

EDGE -B-

Bending Moment, $M_b = 1.1663E+007$

Shear Force, $V_b = 15597.048$

BOTH EDGES

Axial Force, $F = -7208.138$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 709.9999$

-Compression: $As_c = 1668.186$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 709.9999$

-Compression: $As_{c,com} = 1266.062$

-Middle: $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 15.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 475693.923$
 V_n ((22.5.1.1), ACI 318-14) = 475693.923

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw + f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: $V_c = 168236.722$

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 21.64179$, but $f_c^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w * d) = 0.00331157$

A_s (tension reinf.) = 709.9999

$b_w = 400.00$

$d = 536.00$

$V_u * d / M_u < 1 = 0.71681706$

$M_u = 1.1663E+007$

$V_u = 15597.048$

From (11.5.4.8), ACI 318-14: $V_{s1} + V_{s2} = 307457.201$

$V_{s1} = 280648.944$ is calculated for jacket, with:

$d = 536.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$V_{s2} = 26808.257$ is calculated for core, with:

$d = 400.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 300.00$

V_{s2} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f < = 662579.716$

End Of Calculation of Shear Capacity for element: beam JB1 of floor 1

At local axis: 3

Integration Section: (b)

