

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

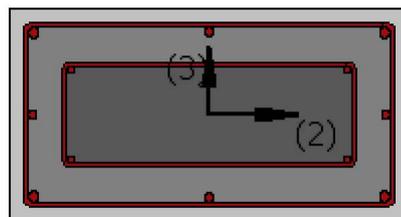
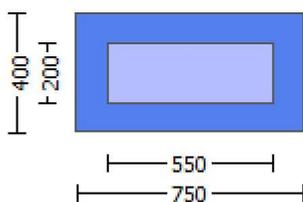
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

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Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of  $\mu$  for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
#####
External Height, H = 400.00
External Width, W = 750.00
Internal Height, H = 200.00
Internal Width, W = 550.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$ 
No FRP Wrapping
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Stepwise Properties
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EDGE -A-
Bending Moment, Ma = -1.1684E+007
Shear Force, Va = -3386.997
EDGE -B-
Bending Moment, Mb = 1.5146E+006
Shear Force, Vb = 3386.997
BOTH EDGES
Axial Force, F = -16097.112
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension: Asl,t = 0.00
  -Compression: Asl,c = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension: Asl,ten = 1137.257
  -Compression: Asl,com = 1137.257
  -Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80
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Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =  $\phi V_n = 683363.019$ 
Vn ((10.3), ASCE 41-17) = knl*VCol = 683363.019
VCol = 683363.019
knl = 1.00
displacement_ductility_demand = 0.02573457
-----
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + \phi \cdot V_f$ '
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).
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= 1 (normal-weight concrete)
Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 21.70$ , but  $f_c'^{0.5} \leq 8.3$ 
MPa (22.5.3.1, ACI 318-14)

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$M/Vd = 4.00$   
 $\mu = 1.1684E+007$   
 $V_u = 3386.997$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16097.112$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 542012.697$   
 where:  
 $V_{s1} = 471238.898$  is calculated for jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s2} = 70773.799$  is calculated for core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 742690.493$   
 $b_w = 400.00$

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 displacement ductility demand is calculated as  $\delta / y$

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

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 From analysis, chord rotation  $\theta = 6.8121454E-005$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00264708$  ((4.29), Biskinis Phd)  
 $M_y = 2.5076E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 3449.669  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.0893E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 28.23333$   
 $N = 16097.112$   
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 3.6310E+014$

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 Calculation of Yielding Moment  $M_y$

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 Calculation of  $\delta / y$  and  $M_y$  according to Annex 7 -

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 $y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.6761016E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/d)^{2/3}) = 296.8915$   
 $d = 707.00$   
 $y = 0.21540464$   
 $A = 0.00965649$   
 $B = 0.00521193$   
 with  $pt = 0.00402142$   
 $pc = 0.00402142$   
 $pv = 0.00142194$   
 $N = 16097.112$   
 $b = 400.00$   
 $\rho = 0.06082037$   
 $y_{comp} = 1.4664753E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.21219612$

A = 0.00933541  
B = 0.00502021  
with Es = 200000.00

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

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

At local axis: 2

Integration Section: (a)

## Calculation No. 2

column C1, Floor 1

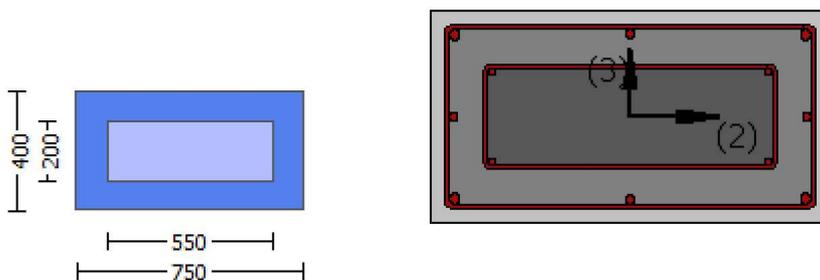
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

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Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
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 = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
#####
External Height, H = 400.00
External Width, W = 750.00
Internal Height, H = 200.00
Internal Width, W = 550.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
No FRP Wrapping
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Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force, Va = -1.3927229E-031
EDGE -B-
Shear Force, Vb = 1.3927229E-031
BOTH EDGES
Axial Force, F = -11016.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Asl,t = 0.00
-Compression: Asl,c = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
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Calculation of Shear Capacity ratio , Ve/Vr = 0.19160863
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 115015.186
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7252E+008
Mu1+ = 1.7252E+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- = 1.7252E+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-) = 1.7252E+008
Mu2+ = 1.7252E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
Mu2- = 1.7252E+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
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Calculation of Mu1+

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Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

$$\mu = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$\phi_w(5.4c) = 0.00183676$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o1} = 690.00$$

$$h_{o1} = 340.00$$

$$b_{i2_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o2} = 542.00$$

$$h_{o2} = 192.00$$

$$b_{i2_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

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

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

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

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

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

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

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

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

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/d  
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Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.7214953E-005$$

$$\mu_1 = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_1: \mu_1^* = \text{shear\_factor} * \text{Max}(\mu_1, \mu_2) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_1 = 0.0052143$$

$$\mu_2 \text{ (5.4c)} = 0.00183676$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.12601038$$

$$\text{ase}_1 = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 1.60339$$

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

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 1.60339$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

$$\text{with } fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 367.9498$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

$$\text{with } fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 367.9498$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

$$\text{with } fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 389.0139$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.04735912$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.04735912$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05619999$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.05619999$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16690234$$

$$Mu = MRc (4.14) = 1.7252E+008$$

$$u = su(4.1) = 1.7214953E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

$$\mu = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu = \text{shear\_factor} * \text{Max}(\mu_c, \mu_s) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.0052143$$

$$\mu_s(5.4c) = 0.00183676$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o1} = 690.00$$

$$h_{o1} = 340.00$$

$$b_{i2_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o2} = 542.00$$

$$h_{o2} = 192.00$$

$$b_{i2_2} = 661256.00$$

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.60339$$

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

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

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

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

$$h_2 = 200.00$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

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

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

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

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

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

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

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } fs_1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9498$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 367.9498$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

characteristic value  $fsy_v = f_{sv}/1.2$ , 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.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$$

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

$$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.04735912$$

$$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.04735912$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / fc) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.05619999$$

$$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.05619999$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / fc) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$\mu_u(4.9) = 0.16690234$

$\mu_u = M_{Rc}(4.14) = 1.7252E+008$

$u = \mu_u(4.1) = 1.7214953E-005$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$

-----  
Calculation of  $\mu_u$ -

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7214953E-005$

$\mu_u = 1.7252E+008$

-----  
with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.0052143$

$\mu_w(5.4c) = 0.00183676$

$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.12601038$

$\alpha_{se1} = 0.12601038$

$b_{o,1} = 690.00$

$h_{o,1} = 340.00$

$b_{i2,1} = 1.1834E+006$

$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$

$b_{o,2} = 542.00$

$h_{o,2} = 192.00$

$b_{i2,2} = 661256.00$

$\mu_{psh,min} * F_{ywe} = \text{Min}(\mu_{psh,x} * F_{ywe}, \mu_{psh,y} * F_{ywe}) = 1.60339$

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

-----  
 $\mu_{psh,x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 1.60339$

$\mu_{psh1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

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

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

$h_1 = 400.00$

$\mu_{psh2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

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

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

$h_2 = 200.00$

-----  
 $\mu_{psh,y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.13667$

$\mu_{psh1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$h_1 = 750.00$

$\mu_{psh2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$

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

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

$h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 555.55$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 441.5397$   
 $fy_1 = 367.9498$   
 $su_1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 0.30$   
 $su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_1\_nominal = 0.08$ ,  
 For calculation of  $esu_1\_nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * A_{sl, ten, jacket} + fs_{core} * A_{sl, ten, core}) / A_{sl, ten} = 367.9498$   
 with  $Es_1 = (Es_{jacket} * A_{sl, ten, jacket} + Es_{core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 441.5397$   
 $fy_2 = 367.9498$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/lb, min = 0.30$   
 $su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_2\_nominal = 0.08$ ,  
 For calculation of  $esu_2\_nominal$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * A_{sl, com, jacket} + fs_{core} * A_{sl, com, core}) / A_{sl, com} = 367.9498$   
 with  $Es_2 = (Es_{jacket} * A_{sl, com, jacket} + Es_{core} * A_{sl, com, core}) / A_{sl, com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * A_{sl, mid, jacket} + fs_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 389.0139$   
 with  $Es_v = (Es_{jacket} * A_{sl, mid, jacket} + Es_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 200000.00$   
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.04735912$   
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.04735912$   
 $v = A_{sl, mid} / (b * d) * (fsv / f_c) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05619999$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05619999$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$$

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

--->  
v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

$$\text{su (4.9)} = 0.16690234$$

$$\text{Mu} = \text{MRc (4.14)} = 1.7252\text{E}+008$$

$$u = \text{su (4.1)} = 1.7214953\text{E}-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 600261.003$

Calculation of Shear Strength at edge 1,  $V_{r1} = 600261.003$

$V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) = knl\*V<sub>Col0</sub>

$$V_{Col0} = 600261.003$$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c\_jacket}*Area\_jacket + f'_{c\_core}*Area\_core)/Area\_section = 28.23333$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\text{Mu} = 1.0002017\text{E}-011$$

$$\text{Vu} = 1.3927229\text{E}-031$$

$$d = 0.8*h = 320.00$$

$$\text{Nu} = 11016.808$$

$$\text{Ag} = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.44$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

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

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$$bw = 750.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 600261.003$

$V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) = knl\*V<sub>Col0</sub>

$$V_{Col0} = 600261.003$$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 1.0002017E-011$   
 $V_u = 1.3927229E-031$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
 where:  
 $V_{s1} = 279254.914$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.44$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$   
 $b_w = 750.00$

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

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

Constant Properties

-----  
 Knowledge Factor,  $\phi = 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
 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,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 Existing Column  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$   
 #####  
 External Height,  $H = 400.00$   
 External Width,  $W = 750.00$

Internal Height, H = 200.00  
Internal Width, W = 550.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 3000.00  
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -3.9443045E-031$   
EDGE -B-  
Shear Force,  $V_b = 3.9443045E-031$   
BOTH EDGES  
Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{st,com} = 1137.257$   
-Middle:  $A_{st,mid} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.25537128$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 3.5366E+008$   
 $Mu_{1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $Mu_{1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 3.5366E+008$   
 $Mu_{2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $Mu_{2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5738376E-006$   
 $M_u = 3.5366E+008$

-----  
with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\phi_o$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$

$a_{se1} = 0.12601038$

$b_{o\_1} = 690.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 1.1834E+006$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$

$b_{o\_2} = 542.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 661256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$

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

-----  
 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$

$ps1$  (external) =  $(A_{sh1} * h1 / s1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h1 = 400.00$

$ps2$  (internal) =  $(A_{sh2} * h2 / s2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h2 = 200.00$

-----  
 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$

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

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h1 = 750.00$

$ps2$  (internal) =  $(A_{sh2} * h2 / s2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h2 = 550.00$

-----  
 $A_{sec} = 300000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 555.55$

$f_{ce} = 33.00$

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

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.5397$

$fy1 = 367.9498$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with  $fs1 = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 367.9498$

with  $Es1 = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 441.5397$

$fy2 = 367.9498$

$su2 = 0.00512$

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

$$\text{Shear\_factor} = 1.00$$

$$l_0/l_{0u,\min} = l_b/l_{b,\min} = 0.30$$

$$s_u2 = 0.4 \cdot \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu2\_nominal} = 0.08,$$

For calculation of esu2\_nominal and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_2 = (fs_{\text{jacket}} \cdot A_{s1,\text{com,jacket}} + fs_{\text{core}} \cdot A_{s1,\text{com,core}}) / A_{s1,\text{com}} = 367.9498$$

$$\text{with } Es_2 = (Es_{\text{jacket}} \cdot A_{s1,\text{com,jacket}} + Es_{\text{core}} \cdot A_{s1,\text{com,core}}) / A_{s1,\text{com}} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_0/l_{0u,\min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 \cdot \text{esuv\_nominal} ((5.5), \text{TBDY}) = 0.032$$

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

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

For calculation of esuv\_nominal and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $fsv = fs_v/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_v = (fs_{\text{jacket}} \cdot A_{s1,\text{mid,jacket}} + fs_{\text{mid}} \cdot A_{s1,\text{mid,core}}) / A_{s1,\text{mid}} = 389.0139$$

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

$$1 = A_{s1,\text{ten}} / (b \cdot d) \cdot (fs_1 / fc) = 0.04483877$$

$$2 = A_{s1,\text{com}} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483877$$

$$v = A_{s1,\text{mid}} / (b \cdot d) \cdot (fs_v / fc) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 33.00$$

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

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

$$1 = A_{s1,\text{ten}} / (b \cdot d) \cdot (fs_1 / fc) = 0.05508907$$

$$2 = A_{s1,\text{com}} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508907$$

$$v = A_{s1,\text{mid}} / (b \cdot d) \cdot (fs_v / fc) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.1553529$$

$$\mu_u = MR_c (4.14) = 3.5366E+008$$

$$u = s_u (4.1) = 8.5738376E-006$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----

-----  
Calculation of  $\mu_{u1}$ -  
-----

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

$$u = 8.5738376E-006$$

$$\mu_u = 3.5366E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.0052143$$

$$\text{we (5.4c) = } 0.00183676$$

$$\text{ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = } 0.12601038$$

$$ase1 = 0.12601038$$

$$bo\_1 = 690.00$$

$$ho\_1 = 340.00$$

$$bi2\_1 = 1.1834E+006$$

$$ase2 = \text{Max}(ase1,ase2) = 0.12601038$$

$$bo\_2 = 542.00$$

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh,\text{min}*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.60339$$

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

$$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.60339$$

$$ps1 \text{ (external) = (Ash1*h1/s1)/Asec = } 0.0020944$$

$$Ash1 = \text{Astir}_1*ns_1 = 157.0796$$

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

$$h1 = 400.00$$

$$ps2 \text{ (internal) = (Ash2*h2/s2)/Asec = } 0.00026808$$

$$Ash2 = \text{Astir}_2*ns_2 = 100.531$$

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

$$h2 = 200.00$$

$$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.13667$$

$$ps1 \text{ (external) = (Ash1*h1/s1)/Asec = } 0.00392699$$

$$Ash1 = \text{Astir}_1*ns_1 = 157.0796$$

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

$$h1 = 750.00$$

$$ps2 \text{ (internal) = (Ash2*h2/s2)/Asec = } 0.00073723$$

$$Ash2 = \text{Astir}_2*ns_2 = 100.531$$

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

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

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

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su1 = 0.4*esu1\_nominal \text{ ((5.5), TBDY) = } 0.032$$

$$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08,$$

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

$$\text{with } fs1 = (fs,\text{jacket}*Asl,\text{ten,jacket} + fs,\text{core}*Asl,\text{ten,core})/Asl,\text{ten} = 367.9498$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9498$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 389.0139$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.04483877$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.04483877$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.05508907$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.05508907$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$su (4.9) = 0.1553529$$

$$Mu = MRc (4.14) = 3.5366E+008$$

$$u = su (4.1) = 8.5738376E-006$$

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30  
-----  
-----

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

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

$$u = 8.5738376E-006$$

$$Mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e \text{ (5.4c)} = 0.00183676$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

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

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 1.60339$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

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

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

with  $fs_1 = (fs_{jacket} \cdot A_{sl,ten,jacket} + fs_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 367.9498$

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/lb_{u,min} = 0.30$

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

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

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

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

with  $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 367.9498$

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.30$

$su_v = 0.4 \cdot esuv_{nominal} ((5.5), \text{TBDY}) = 0.032$

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

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

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

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

with  $fs_v = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 389.0139$

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04483877$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483877$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.01676222$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

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

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

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05508907$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508907$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$su (4.9) = 0.1553529$

$Mu = MRc (4.14) = 3.5366E+008$

$u = su (4.1) = 8.5738376E-006$

-----  
Calculation of ratio  $lb/ld$

-----  
Inadequate Lap Length with  $lb/ld = 0.30$   
-----  
-----  
-----

-----  
Calculation of  $Mu_2$ -  
-----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$\mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$\phi_{we} \text{ (5.4c)} = 0.00183676$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

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

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$s_u1 = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s1\_nominal} = 0.08,$$

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.

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

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9498$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$s_u2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

$$\text{Shear\_factor} = 1.00$$

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

$$s_u2 = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s2\_nominal} = 0.08,$$

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.

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

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 367.9498$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

$$\text{Shear\_factor} = 1.00$$

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

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

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

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.

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

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04483877$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04483877$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05508907$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05508907$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.1553529$$

$$\mu = M R_c (4.14) = 3.5366E+008$$

$$u = s_u (4.1) = 8.5738376E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

-----  
-----  
-----  
-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 923245.821$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 923245.821$

$V_{r1} = V_{Co1} ((10.3), \text{ASCE } 41-17) = knl * V_{Co10}$

$V_{Co10} = 923245.821$

$kn1 = 1$  (zero step-static loading)

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

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

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 6.8236829E-012$

$V_u = 3.9443045E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{s2} = 78636.768$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 1.00$

$s/d = 0.56818182$

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

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$bw = 400.00$   
-----

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 923245.821$

$V_{r2} = V_{Co2} ((10.3), \text{ASCE } 41-17) = knl * V_{Co10}$

$V_{Co10} = 923245.821$

$kn1 = 1$  (zero step-static loading)

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

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

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 6.8236829E-012$

$V_u = 3.9443045E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.16666667

Vs2 = 78636.768 is calculated for core, with:

d = 440.00

Av = 100530.965

fy = 444.44

s = 250.00

Vs2 is multiplied by Col2 = 1.00

s/d = 0.56818182

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

From (11-11), ACI 440: Vs + Vf <= 847147.582

bw = 400.00

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

At local axis: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

-----  
Knowledge Factor, = 1.00

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$

No FRP Wrapping

-----  
Stepwise Properties

-----  
Bending Moment,  $M = 1.1088903E-009$

Shear Force,  $V_2 = -3386.997$

Shear Force,  $V_3 = -3.7626771E-013$

Axial Force,  $F = -16097.112$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl,ten = 1137.257$

-Compression:  $Asl,com = 1137.257$

-Middle:  $Asl,mid = 402.1239$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl,ten,jacket = 829.3805$

-Compression:  $Asl,com,jacket = 829.3805$

-Middle:  $Asl,mid,jacket = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl,ten,core = 307.8761$

-Compression:  $Asl,com,core = 307.8761$

-Middle:  $Asl,mid,core = 0.00$

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u,R = u = 0.00198322$   
 $u = y + p = 0.00198322$

- Calculation of  $y$  -

$y = (My*Ls/3)/Eleff = 0.00198322 ((4.29),Biskinis Phd)$

$My = 1.2590E+008$

$Ls = M/V$  (with  $Ls > 0.1*L$  and  $Ls < 2*L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $Eleff = factor*Ec*Ig = 3.1741E+013$

factor = 0.30

$Ag = 300000.00$

Mean concrete strength:  $fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.23333$

$N = 16097.112$

$Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.0580E+014$

Calculation of Yielding Moment  $My$

Calculation of  $y$  and  $My$  according to Annex 7 -

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

$y_{ten} = 5.3808581E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25*f_y*(lb/d)^{2/3}) = 296.8915$

$d = 357.00$

$y = 0.22723402$

$A = 0.01019927$

$B = 0.00580293$

with  $pt = 0.00424746$

$pc = 0.00424746$

$p_v = 0.00150186$

$N = 16097.112$

$b = 750.00$

$" = 0.12044818$

$y_{comp} = 2.7496413E-005$

with  $fc = 33.00$

$Ec = 26999.444$

$y = 0.22412348$

$A = 0.00986014$

$B = 0.00560044$

with  $Es = 200000.00$

Calculation of ratio  $lb/d$

Inadequate Lap Length with  $lb/d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00$

with:

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

shear control ratio  $V_y E / V_{Col} O E = 0.19160863$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 * t_f / b w * (f_{fe} / f_s) = 0.00236248$

jacket:  $s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.0020944$

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

$h_1 = 400.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00026808$

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

$h_2 = 200.00$

$s_2 = 250.00$

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

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

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

For the normalisation  $f_s$  of jacket is used.

$N U D = 16097.112$

$A_g = 300000.00$

$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section\_area = 28.23333$

$f_{yIE} = (f_{y,ext\_Long\_Reinf} * Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} * Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 529.9972$

$f_{ytE} = (f_{y,ext\_Trans\_Reinf} * s_1 + f_{y,int\_Trans\_Reinf} * s_2) / (s_1 + s_2) = 542.9506$

$p_l = Area_{Tot\_Long\_Rein} / (b * d) = 0.00999678$

$b = 750.00$

$d = 357.00$

$f_{cE} = 28.23333$

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

At local axis: 2

Integration Section: (a)

### Calculation No. 3

column C1, Floor 1

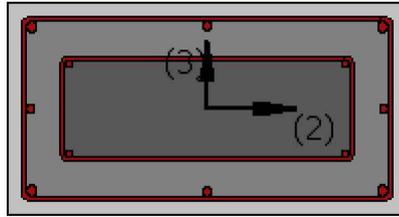
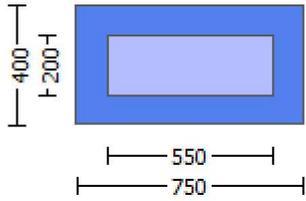
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

Existing material: Steel Strength,  $f_s = f_{sm} = 444.44$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 1.1088903E-009$

Shear Force,  $V_a = -3.7626771E-013$

EDGE -B-

Bending Moment, Mb = 2.2170426E-011

Shear Force, Vb = 3.7626771E-013

BOTH EDGES

Axial Force, F = -16097.112

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 2676.637

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257

-Compression: Asl,com = 1137.257

-Middle: Asl,mid = 402.1239

Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR = \*Vn = 534028.057

Vn ((10.3), ASCE 41-17) = knl\*VColO = 534028.057

VCol = 534028.057

knl = 1.00

displacement\_ductility\_demand = 0.00

NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 21.70, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.1088903E-009

Vu = 3.7626771E-013

d = 0.8\*h = 320.00

Nu = 16097.112

Ag = 300000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412

where:

Vs1 = 251327.412 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 500.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 400.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 742690.493

bw = 750.00

displacement\_ductility\_demand is calculated as / y

- Calculation of / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation = 1.8329987E-020

y = (My\*Ls/3)/Eleff = 0.00198322 ((4.29),Biskinis Phd))

My = 1.2590E+008

Ls = M/V (with Ls > 0.1\*L and Ls < 2\*L) = 1500.00

From table 10.5, ASCE 41\_17: Eleff = factor\*Ec\*lg = 3.1741E+013

factor = 0.30  
Ag = 300000.00  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$   
N = 16097.112  
 $E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 1.0580E+014$

Calculation of Yielding Moment My

Calculation of  $y$  and My according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 5.3808581E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 296.8915$   
d = 357.00  
y = 0.22723402  
A = 0.01019927  
B = 0.00580293  
with pt = 0.00424746  
pc = 0.00424746  
pv = 0.00150186  
N = 16097.112  
b = 750.00  
" = 0.12044818  
 $y_{\text{comp}} = 2.7496413E-005$   
with fc = 33.00  
Ec = 26999.444  
y = 0.22412348  
A = 0.00986014  
B = 0.00560044  
with Es = 200000.00

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

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

At local axis: 3

Integration Section: (a)

## Calculation No. 4

column C1, Floor 1

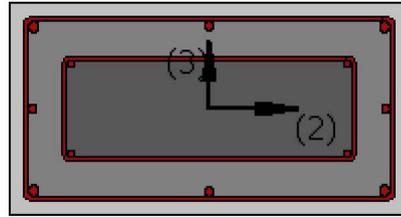
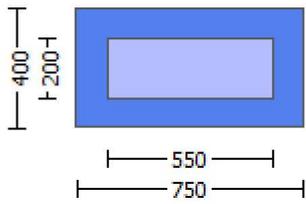
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

Edge: Start

Local Axis: (3)



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

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

Constant Properties

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

Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
 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,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 Existing Column  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$   
 External Width,  $W = 750.00$   
 Internal Height,  $H = 200.00$   
 Internal Width,  $W = 550.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.00  
 Element Length,  $L = 3000.00$

Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{ou, \min} = 0.30$   
 No FRP Wrapping

Stepwise Properties

At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -1.3927229E-031$   
 EDGE -B-  
 Shear Force,  $V_b = 1.3927229E-031$   
 BOTH EDGES

Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{,ten} = 1137.257$   
-Compression:  $As_{,com} = 1137.257$   
-Middle:  $As_{,mid} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 0.19160863$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 115015.186$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7252E+008$   
 $Mu_{1+} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{1-} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7252E+008$   
 $Mu_{2+} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{2-} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 1.7214953E-005$   
 $M_u = 1.7252E+008$

-----  
with full section properties:

$b = 750.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\phi_c$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.0052143$   
 $\phi_w$  (5.4c) = 0.00183676  
 $\phi_{ase}$  ((5.4d), TBDY) =  $(\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.12601038$   
 $\phi_{ase1} = 0.12601038$   
 $\phi_{bo\_1} = 690.00$   
 $\phi_{ho\_1} = 340.00$   
 $\phi_{bi2\_1} = 1.1834E+006$   
 $\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.12601038$   
 $\phi_{bo\_2} = 542.00$   
 $\phi_{ho\_2} = 192.00$   
 $\phi_{bi2\_2} = 661256.00$   
 $\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 1.60339$   
Expression ((5.4d), TBDY) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 1.60339$   
 $\phi_{ps1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
No stirrups,  $n_{s\_1} = 2.00$   
 $h_1 = 400.00$   
 $\phi_{ps2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 389.0139$

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04735912$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04735912$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01770442$

and confined core properties:

$b = 690.00$

$d = 327.00$

$d' = 13.00$

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

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

$c$  = confinement factor = 1.00

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05619999$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05619999$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$su$  (4.9) = 0.16690234

$Mu = MRc$  (4.14) = 1.7252E+008

$u = su$  (4.1) = 1.7214953E-005

-----  
Calculation of ratio  $lb/ld$

-----  
Inadequate Lap Length with  $lb/ld = 0.30$   
-----  
-----

-----  
Calculation of  $Mu_1$ -  
-----  
-----

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

$u = 1.7214953E-005$

$Mu = 1.7252E+008$   
-----

with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.0052143$

we (5.4c) = 0.00183676

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.12601038$

$ase_1 = 0.12601038$

$bo_1 = 690.00$

$ho_1 = 340.00$

$bi_2_1 = 1.1834E+006$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$

$bo_2 = 542.00$

$ho_2 = 192.00$

$bi_2_2 = 661256.00$

$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 1.60339$

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

-----  
 $psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 1.60339$   
-----

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.0020944$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00026808$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 200.00$$

---

$$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00073723$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 550.00$$

---

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

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

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 367.9498$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

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.

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 367.9498$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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  $\gamma_v$ ,  $sh_v, ft_v, fy_v$ , it is considered

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

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

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04735912$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04735912$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05619999$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05619999$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.16690234$$

$$\mu_u = M_{Rc} (4.14) = 1.7252E+008$$

$$u = s_u (4.1) = 1.7214953E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

$$\mu_u = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e (5.4c) = 0.00183676$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 1.60339$$

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

$$psh_x * Fy_{we} = psh_1 * Fy_{we1} + ps_2 * Fy_{we2} = 1.60339$$

$$ps_1 \text{ (external)} = (Ash_1 * h_1 / s_1) / A_{sec} = 0.0020944$$

$$Ash_1 = Astir_1 * ns_1 = 157.0796$$

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

$$h_1 = 400.00$$

$$ps_2 \text{ (internal)} = (Ash_2 * h_2 / s_2) / A_{sec} = 0.00026808$$

$$Ash_2 = Astir_2 * ns_2 = 100.531$$

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

$$h_2 = 200.00$$

$$psh_y * Fy_{we} = psh_1 * Fy_{we1} + ps_2 * Fy_{we2} = 3.13667$$

$$ps_1 \text{ (external)} = (Ash_1 * h_1 / s_1) / A_{sec} = 0.00392699$$

$$Ash_1 = Astir_1 * ns_1 = 157.0796$$

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

$$h_1 = 750.00$$

$$ps_2 \text{ (internal)} = (Ash_2 * h_2 / s_2) / A_{sec} = 0.00073723$$

$$Ash_2 = Astir_2 * ns_2 = 100.531$$

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

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{min} = lb/l_{d,min} = 0.30$$

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

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

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

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

$$\text{with } fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{min} = lb/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9498$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$f_{yv} = 389.0139$   
 $s_{uv} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $\gamma_v$ ,  $sh_v, ft_v, f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $\gamma_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$   
 with  $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04735912$   
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04735912$   
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05619999$   
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05619999$   
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16690234$   
 $Mu = MRc (4.14) = 1.7252E+008$   
 $u = su (4.1) = 1.7214953E-005$

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 Calculation of ratio  $l_b/l_d$

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 Inadequate Lap Length with  $l_b/l_d = 0.30$   
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 Calculation of  $Mu_2$ -  
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 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7214953E-005$   
 $Mu = 1.7252E+008$

-----  
 with full section properties:

$b = 750.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, cc) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.0052143$   
 $w_e (5.4c) = 0.00183676$   
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$

$$bi2\_1 = 1.1834E+006$$

$$ase2 = \text{Max}(ase1, ase2) = 0.12601038$$

$$bo\_2 = 542.00$$

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh, \text{min} * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 1.60339$$

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

$$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.60339$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.0020944$$

$$Ash1 = Astir\_1 * ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00026808$$

$$Ash2 = Astir\_2 * ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 200.00$$

$$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir\_1 * ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00073723$$

$$Ash2 = Astir\_2 * ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su1 = 0.4 * esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 367.9498$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su2 = 0.4 * esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  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.

$$\text{with } fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9498$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  

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

$$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$$
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $yv, shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1,ft_1,fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  

$$\text{with } fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$$

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

$$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04735912$$

$$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04735912$$

$$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01770442$$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05619999$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05619999$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$su (4.9) = 0.16690234$   
 $Mu = MRc (4.14) = 1.7252E+008$   
 $u = su (4.1) = 1.7214953E-005$

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 Calculation of ratio  $lb/ld$

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 Inadequate Lap Length with  $lb/ld = 0.30$   
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-----  
 Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 600261.003$   
 -----

-----  
 Calculation of Shear Strength at edge 1,  $V_{r1} = 600261.003$

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

$V_{Col0} = 600261.003$

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

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

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

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 28.23333$ , but  $fc'^{0.5} < =$   
 8.3 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 1.0002017E-011$

$Vu = 1.3927229E-031$

$d = 0.8 \cdot h = 320.00$

$Nu = 11016.808$

Ag = 300000.00  
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
where:  
Vs1 = 279254.914 is calculated for jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.3125  
Vs2 = 0.00 is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$   
bw = 750.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 600261.003  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 600261.003  
knl = 1 (zero step-static loading)

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

-----  
= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_{c'}^{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_{c'}^{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00  
Mu = 1.0002017E-011  
Vu = 1.3927229E-031  
d = 0.8\*h = 320.00  
Nu = 11016.808  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
where:  
Vs1 = 279254.914 is calculated for jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.3125  
Vs2 = 0.00 is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$   
bw = 750.00

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

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

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

Constant Properties

Knowledge Factor,  $\phi = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

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,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -3.9443045E-031$

EDGE -B-

Shear Force,  $V_b = 3.9443045E-031$

BOTH EDGES

Axial Force,  $F = -11016.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-Compression:  $A_{slc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.25537128$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$

with

$$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.5366E+008$$

$Mu_{1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.5366E+008$$

$Mu_{2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 8.5738376E-006$$

$$Mu = 3.5366E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$\omega_e (5.4c) = 0.00183676$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

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

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } fs_1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9498$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 367.9498$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

$$\text{with } fsv = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$$

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

$$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.04483877$$

$$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.04483877$$

$$v = A_{s,mid} / (b * d) * (fsv / fc) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.05508907$$

$$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.05508907$$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02059413$$

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

--->

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

--->

$$s_u(4.9) = 0.1553529$$

$$M_u = M_{Rc}(4.14) = 3.5366E+008$$

$$u = s_u(4.1) = 8.5738376E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $M_{u1}$ -

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

$$u = 8.5738376E-006$$

$$M_u = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e(5.4c) = 0.00183676$$

$$a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 1.60339$$

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

$$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} \cdot n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} \cdot n_{s\_2} = 100.531$$

No stirrups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04483877

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04483877

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01676222

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 33.00  
 $c_c$  (5A.5, TBDY) = 0.002  
 $c$  = confinement factor = 1.00  
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05508907$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508907$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

$\mu_u$  (4.9) = 0.1553529  
 $\mu_u = M_{Rc}$  (4.14) = 3.5366E+008  
 $u = \mu_u$  (4.1) = 8.5738376E-006

-----  
 Calculation of ratio  $l_b/l_d$

-----  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----

-----  
 Calculation of  $\mu_{u2+}$   
 -----

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

$u = 8.5738376E-006$   
 $\mu_u = 3.5366E+008$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $c_c$  (5A.5, TBDY) = 0.002  
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.0052143$   
 $w_e$  (5.4c) = 0.00183676  
 $a_{se}$  ((5.4d), TBDY) =  $(a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $b_{o,1} = 690.00$   
 $h_{o,1} = 340.00$   
 $b_{i2,1} = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $b_{o,2} = 542.00$   
 $h_{o,2} = 192.00$   
 $b_{i2,2} = 661256.00$   
 $p_{sh,min}*F_{ywe} = \text{Min}(p_{sh,x}*F_{ywe}, p_{sh,y}*F_{ywe}) = 1.60339$   
 Expression ((5.4d), TBDY) for  $p_{sh,min}*F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $p_{sh,x}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 1.60339$   
 $ps_1$  (external) =  $(A_{sh1}*h_1/s_1)/A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1}*n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 400.00$   
 $ps_2$  (internal) =  $(A_{sh2}*h_2/s_2)/A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2}*n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 200.00$

-----  
 $p_{sh,y}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 3.13667$   
 $ps_1$  (external) =  $(A_{sh1}*h_1/s_1)/A_{sec} = 0.00392699$

$$\text{Ash1} = \text{Astir}_1 * \text{ns}_1 = 157.0796$$

$$\text{No stirups, ns}_1 = 2.00$$

$$h1 = 750.00$$

$$\text{ps2 (internal)} = (\text{Ash2} * h2 / s2) / \text{Asec} = 0.00073723$$

$$\text{Ash2} = \text{Astir}_2 * \text{ns}_2 = 100.531$$

$$\text{No stirups, ns}_2 = 2.00$$

$$h2 = 550.00$$

---

$$\text{Asec} = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$\text{fywe1} = 694.45$$

$$\text{fywe2} = 555.55$$

$$\text{fce} = 33.00$$

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

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

$$y1 = 0.00140044$$

$$\text{sh1} = 0.0044814$$

$$\text{ft1} = 441.5397$$

$$\text{fy1} = 367.9498$$

$$\text{su1} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$\text{su1} = 0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu1\_nominal} = 0.08,$$

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

$$\text{with fs1} = (\text{fs,jacket} * \text{Asl,ten,jacket} + \text{fs,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 367.9498$$

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

$$y2 = 0.00140044$$

$$\text{sh2} = 0.0044814$$

$$\text{ft2} = 441.5397$$

$$\text{fy2} = 367.9498$$

$$\text{su2} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$\text{su2} = 0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu2\_nominal} = 0.08,$$

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

$$\text{with fs2} = (\text{fs,jacket} * \text{Asl,com,jacket} + \text{fs,core} * \text{Asl,com,core}) / \text{Asl,com} = 367.9498$$

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

$$yv = 0.00140044$$

$$\text{shv} = 0.0044814$$

$$\text{ftv} = 466.8167$$

$$\text{fyv} = 389.0139$$

$$\text{suv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

$$\text{with fsv} = (\text{fs,jacket} * \text{Asl,mid,jacket} + \text{fs,mid} * \text{Asl,mid,core}) / \text{Asl,mid} = 389.0139$$

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

$$1 = \text{Asl,ten} / (\text{b} * \text{d}) * (\text{fs1} / \text{fc}) = 0.04483877$$

$$2 = \text{Asl,com} / (\text{b} * \text{d}) * (\text{fs2} / \text{fc}) = 0.04483877$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05508907$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508907$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.1553529$$

$$M_u = M_{Rc} (4.14) = 3.5366E+008$$

$$u = s_u (4.1) = 8.5738376E-006$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $M_{u2}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$M_u = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e (5.4c) = 0.00183676$$

$$a_{se} ((5.4d), TBDY) = (a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh,min}*F_{ywe} = \text{Min}(p_{sh,x}*F_{ywe}, p_{sh,y}*F_{ywe}) = 1.60339$$

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

$$p_{sh,x}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 1.60339$$

$$p_{s1} (\text{external}) = (A_{sh1}*h_1/s_1)/A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1}*n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2}*h_2/s_2)/A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2}*n_{s\_2} = 100.531$$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 200.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.13667  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00392699  
Ash<sub>1</sub> = Astir<sub>1</sub>\*ns<sub>1</sub> = 157.0796  
No stirups, ns<sub>1</sub> = 2.00  
h<sub>1</sub> = 750.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00073723  
Ash<sub>2</sub> = Astir<sub>2</sub>\*ns<sub>2</sub> = 100.531  
No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 550.00

Asec = 300000.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.45

fywe<sub>2</sub> = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y<sub>1</sub> = 0.00140044

sh<sub>1</sub> = 0.0044814

ft<sub>1</sub> = 441.5397

fy<sub>1</sub> = 367.9498

su<sub>1</sub> = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>d</sub> = 0.30

su<sub>1</sub> = 0.4\*esu<sub>1\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>1\_nominal</sub> = 0.08,

For calculation of esu<sub>1\_nominal</sub> and y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, it is considered  
characteristic value fsy<sub>1</sub> = fs<sub>1</sub>/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>1</sub> = (fs<sub>jacket</sub>\*As<sub>l,ten,jacket</sub> + fs<sub>core</sub>\*As<sub>l,ten,core</sub>)/As<sub>l,ten</sub> = 367.9498

with Es<sub>1</sub> = (Es<sub>jacket</sub>\*As<sub>l,ten,jacket</sub> + Es<sub>core</sub>\*As<sub>l,ten,core</sub>)/As<sub>l,ten</sub> = 200000.00

y<sub>2</sub> = 0.00140044

sh<sub>2</sub> = 0.0044814

ft<sub>2</sub> = 441.5397

fy<sub>2</sub> = 367.9498

su<sub>2</sub> = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>b,min</sub> = 0.30

su<sub>2</sub> = 0.4\*esu<sub>2\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>2\_nominal</sub> = 0.08,

For calculation of esu<sub>2\_nominal</sub> and y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, it is considered  
characteristic value fsy<sub>2</sub> = fs<sub>2</sub>/1.2, from table 5.1, TBDY.

y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>2</sub> = (fs<sub>jacket</sub>\*As<sub>l,com,jacket</sub> + fs<sub>core</sub>\*As<sub>l,com,core</sub>)/As<sub>l,com</sub> = 367.9498

with Es<sub>2</sub> = (Es<sub>jacket</sub>\*As<sub>l,com,jacket</sub> + Es<sub>core</sub>\*As<sub>l,com,core</sub>)/As<sub>l,com</sub> = 200000.00

y<sub>v</sub> = 0.00140044

sh<sub>v</sub> = 0.0044814

ft<sub>v</sub> = 466.8167

fy<sub>v</sub> = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>d</sub> = 0.30

suv = 0.4\*esuv<sub>nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv<sub>nominal</sub> = 0.08,

considering characteristic value fsy<sub>v</sub> = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv<sub>nominal</sub> and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsy<sub>v</sub> = fsv/1.2, from table 5.1, TBDY.

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

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$

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

1 =  $Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04483877$

2 =  $Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483877$

v =  $Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01676222$

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05508907$

2 =  $Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508907$

v =  $Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.1553529

Mu = MRc (4.14) = 3.5366E+008

u = su (4.1) = 8.5738376E-006

-----  
Calculation of ratio lb/d

-----  
Inadequate Lap Length with lb/d = 0.30  
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 923245.821$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 923245.821$

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

$V_{Col0} = 923245.821$

knl = 1 (zero step-static loading)

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

-----  
= 1 (normal-weight concrete)

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 28.23333$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

M/d = 2.00

Mu = 6.8236829E-012

Vu = 3.9443045E-031

d = 0.8 \* h = 600.00

Nu = 11016.808

Ag = 300000.00

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

d = 600.00

$A_v = 157079.633$

$f_y = 555.56$

s = 100.00

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

s/d = 0.16666667

$V_{s2} = 78636.768$  is calculated for core, with:

d = 440.00

$A_v = 100530.965$

$f_y = 444.44$

s = 250.00

$V_{s2}$  is multiplied by Col2 = 1.00

s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 847147.582  
bw = 400.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 923245.821  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 923245.821  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*VF'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 28.23333, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 6.8236829E-012

Vu = 3.9443045E-031

d = 0.8\*h = 600.00

Nu = 11016.808

Ag = 300000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 602239.733

where:

Vs1 = 523602.964 is calculated for jacket, with:

d = 600.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.16666667

Vs2 = 78636.768 is calculated for core, with:

d = 440.00

Av = 100530.965

fy = 444.44

s = 250.00

Vs2 is multiplied by Col2 = 1.00

s/d = 0.56818182

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

From (11-11), ACI 440: Vs + Vf <= 847147.582

bw = 400.00

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

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

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

-----  
Knowledge Factor, = 1.00

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

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

Consequently:

Jacket

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

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$   
 External Height,  $H = 400.00$   
 External Width,  $W = 750.00$   
 Internal Height,  $H = 200.00$   
 Internal Width,  $W = 550.00$   
 Cover Thickness,  $c = 25.00$   
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 No FRP Wrapping

-----  
 Stepwise Properties  
 -----

Bending Moment,  $M = -1.1684E+007$   
 Shear Force,  $V_2 = -3386.997$   
 Shear Force,  $V_3 = -3.7626771E-013$   
 Axial Force,  $F = -16097.112$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{st} = 0.00$   
 -Compression:  $A_{sc} = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st,ten} = 1137.257$   
 -Compression:  $A_{st,com} = 1137.257$   
 -Middle:  $A_{st,mid} = 402.1239$   
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st,ten,jacket} = 829.3805$   
 -Compression:  $A_{st,com,jacket} = 829.3805$   
 -Middle:  $A_{st,mid,jacket} = 402.1239$   
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st,ten,core} = 307.8761$   
 -Compression:  $A_{st,com,core} = 307.8761$   
 -Middle:  $A_{st,mid,core} = 0.00$   
 Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

-----  
 Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = \phi_u = 0.00264708$   
 $\phi_u = \phi_y + \phi_p = 0.00264708$

-----  
 - Calculation of  $\phi_y$  -  
 -----

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00264708$  ((4.29), Biskinis Phd))  
 $M_y = 2.5076E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3449.669  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.0893E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
 Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 28.23333$   
 $N = 16097.112$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.6310E+014$

-----  
 Calculation of Yielding Moment  $M_y$   
 -----

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -  
 -----

```

y = Min( y_ten, y_com)
y_ten = 2.6761016E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/d)^ 2/3) = 296.8915
d = 707.00
y = 0.21540464
A = 0.00965649
B = 0.00521193
with pt = 0.00402142
pc = 0.00402142
pv = 0.00142194
N = 16097.112
b = 400.00
" = 0.06082037
y_comp = 1.4664753E-005
with fc = 33.00
Ec = 26999.444
y = 0.21219612
A = 0.00933541
B = 0.00502021
with Es = 200000.00

```

-----

Calculation of ratio lb/d

-----

Inadequate Lap Length with lb/d = 0.30

-----

- Calculation of  $p$  -

-----

From table 10-8:  $p = 0.00$

with:

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

shear control ratio  $VyE/VCoIE = 0.25537128$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

$t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00466422$

jacket:  $s1 = Av1*h1/(s1*Ag) = 0.00392699$

$Av1 = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$h1 = 750.00$

$s1 = 100.00$

core:  $s2 = Av2*h2/(s2*Ag) = 0.00073723$

$Av2 = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$h2 = 550.00$

$s2 = 250.00$

The term  $2*tf/bw*(ffe/fs)$  is implemented to account for FRP contribution

where  $f = 2*tf/bw$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $ffe/fs$  normalises  $f$  to steel strength

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

For the normalisation  $fs$  of jacket is used.

$NUD = 16097.112$

$Ag = 300000.00$

$f_{cE} = (fc_{jacket}*Area_{jacket} + fc_{core}*Area_{core})/section\_area = 28.23333$

$fyIE = (fy_{ext\_Long\_Reinf}*Area_{ext\_Long\_Reinf} + fy_{int\_Long\_Reinf}*Area_{int\_Long\_Reinf})/Area_{Tot\_Long\_Rein} = 529.9972$

$fytE = (fy_{ext\_Trans\_Reinf}*s1 + fy_{int\_Trans\_Reinf}*s2)/(s1 + s2) = 537.9964$

$pl = Area_{Tot\_Long\_Rein}/(b*d) = 0.00946477$

$b = 400.00$

$d = 707.00$

$f_{cE} = 28.23333$

-----

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

At local axis: 3

Integration Section: (a)

-----

## Calculation No. 5

column C1, Floor 1

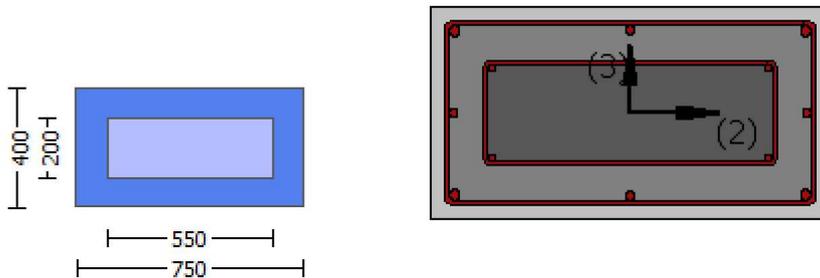
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material: Steel Strength,  $f_s = f_{sm} = 444.44$   
 #####  
 External Height,  $H = 400.00$   
 External Width,  $W = 750.00$   
 Internal Height,  $H = 200.00$   
 Internal Width,  $W = 550.00$   
 Cover Thickness,  $c = 25.00$   
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 No FRP Wrapping

-----  
 Stepwise Properties  
 -----

EDGE -A-  
 Bending Moment,  $M_a = -1.1684E+007$   
 Shear Force,  $V_a = -3386.997$   
 EDGE -B-  
 Bending Moment,  $M_b = 1.5146E+006$   
 Shear Force,  $V_b = 3386.997$   
 BOTH EDGES  
 Axial Force,  $F = -16097.112$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{st} = 0.00$   
 -Compression:  $A_{sc} = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st,ten} = 1137.257$   
 -Compression:  $A_{st,com} = 1137.257$   
 -Middle:  $A_{st,mid} = 402.1239$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

-----  
 Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 824713.342$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI0} = 824713.342$   
 $V_{CoI} = 824713.342$   
 $k_n = 1.00$   
 displacement\_ductility\_demand = 0.05850534  
 -----

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

= 1 (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 21.70$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 1.5146E+006$   
 $V_u = 3386.997$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16097.112$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 542012.697$   
 where:  
 $V_{s1} = 471238.898$  is calculated for jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $CoI1 = 1.00$   
 $s/d = 0.16666667$

Vs2 = 70773.799 is calculated for core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.56818182$$

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

From (11-11), ACI 440: Vs + Vf <= 742690.493

$$b_w = 400.00$$

displacement ductility demand is calculated as  $\delta / y$

- Calculation of  $\delta / y$  for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 2.0075307E-005

$$y = (M_y * L_s / 3) / E_{eff} = 0.00034314 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 2.5076E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 447.1746$$

From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} * E_c * I_g = 1.0893E+014$

$$\text{factor} = 0.30$$

$$A_g = 300000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{jacket} * A_{jacket} + f_c'_{core} * A_{core}) / A_{section} = 28.23333$$

$$N = 16097.112$$

$$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.6310E+014$$

Calculation of Yielding Moment  $M_y$

Calculation of  $\delta / y$  and  $M_y$  according to Annex 7 -

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

$$y_{ten} = 2.6761016E-006$$

$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 296.8915$$

$$d = 707.00$$

$$y = 0.21540464$$

$$A = 0.00965649$$

$$B = 0.00521193$$

$$\text{with } p_t = 0.00402142$$

$$p_c = 0.00402142$$

$$p_v = 0.00142194$$

$$N = 16097.112$$

$$b = 400.00$$

$$" = 0.06082037$$

$$y_{comp} = 1.4664753E-005$$

with  $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.21219612$$

$$A = 0.00933541$$

$$B = 0.00502021$$

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

Calculation of ratio  $l_b / d$

Inadequate Lap Length with  $l_b / d = 0.30$

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

At local axis: 2

Integration Section: (b)

## Calculation No. 6

column C1, Floor 1

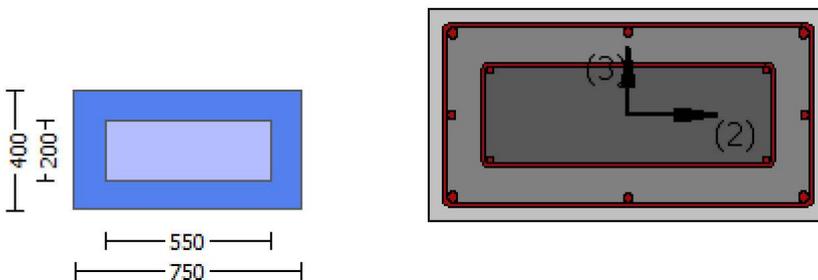
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\mu$ )

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

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,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$   
Internal Height,  $H = 200.00$   
Internal Width,  $W = 550.00$   
Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.00  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -1.3927229E-031$   
EDGE -B-  
Shear Force,  $V_b = 1.3927229E-031$   
BOTH EDGES  
Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1137.257$   
-Compression:  $As_{c,com} = 1137.257$   
-Middle:  $As_{mid} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19160863$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 115015.186$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.7252E+008$   
 $Mu_{1+} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $Mu_{1-} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.7252E+008$   
 $Mu_{2+} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $Mu_{2-} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 1.7214953E-005$   
 $M_u = 1.7252E+008$

-----  
with full section properties:

$b = 750.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha_1(5A_s, TBDY) = 0.002$

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$

$a_{se1} = 0.12601038$

$b_{o\_1} = 690.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 1.1834E+006$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$

$b_{o\_2} = 542.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 661256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$

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

-----  
 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

-----  
 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$

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

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 750.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 550.00$

-----  
 $A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 555.55$

$f_{ce} = 33.00$

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

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.5397$

$fy_1 = 367.9498$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 367.9498$

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30

-----  
Calculation of Mu1-

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

u = 1.7214953E-005

Mu = 1.7252E+008

-----  
with full section properties:

b = 750.00

d = 357.00

$d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.0052143$   
 $w_e (5.4c) = 0.00183676$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase2 = Max(ase1, ase2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$   
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.60339$   
 Expression ((5.4d), TBDY) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.60339$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.0020944$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00026808$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 200.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.13667$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00073723$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 550.00$

$A_{sec} = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 555.55$   
 $fce = 33.00$

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

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.5397$   
 $fy1 = 367.9498$   
 $su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lo_{u,min} = lb/d = 0.30$

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

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

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

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

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$

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

$y2 = 0.00140044$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 0.30$$

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

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

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

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

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9498$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$$

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.04735912$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.04735912$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

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

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

$c$  = confinement factor = 1.00

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.05619999$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05619999$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16690234$$

$$\mu_u = M_{Rc} (4.14) = 1.7252E+008$$

$$u = su (4.1) = 1.7214953E-005$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $\mu_{u2+}$

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

$$u = 1.7214953E-005$$

Mu = 1.7252E+008

with full section properties:

b = 750.00

d = 357.00

d' = 43.00

v = 0.00124684

N = 11016.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.0052143

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038

ase1 = 0.12601038

bo\_1 = 690.00

ho\_1 = 340.00

bi2\_1 = 1.1834E+006

ase2 = Max(ase1,ase2) = 0.12601038

bo\_2 = 542.00

ho\_2 = 192.00

bi2\_2 = 661256.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339

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

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339

ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944

Ash1 = Astir\_1\*ns\_1 = 157.0796

No stirrups, ns\_1 = 2.00

h1 = 400.00

ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808

Ash2 = Astir\_2\*ns\_2 = 100.531

No stirrups, ns\_2 = 2.00

h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667

ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699

Ash1 = Astir\_1\*ns\_1 = 157.0796

No stirrups, ns\_1 = 2.00

h1 = 750.00

ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723

Ash2 = Astir\_2\*ns\_2 = 100.531

No stirrups, ns\_2 = 2.00

h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered

characteristic value  $f_{s1} = f_s/1.2$ , from table 5.1, TBDY.

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

with  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 367.9498$

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{d,min} = 0.30$

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

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

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered

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

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

with  $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 367.9498$

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

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

$su_v = 0.4 \cdot esu_{v,nominal} ((5.5), TBDY) = 0.032$

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

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

For calculation of  $esu_{v,nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 389.0139$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.04735912$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.04735912$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.01770442$

and confined core properties:

$b = 690.00$

$d = 327.00$

$d' = 13.00$

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

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

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05619999$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05619999$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$su (4.9) = 0.16690234$

$Mu = MRc (4.14) = 1.7252E+008$

$u = su (4.1) = 1.7214953E-005$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$

-----  
Calculation of  $Mu_2$ -

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

$$\mu = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$\phi_w(5.4c) = 0.00183676$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 1.60339$$

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

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 1.60339$$

$$\phi_{sh1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$\phi_{sh2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/d  
-----

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 600261.003$

Calculation of Shear Strength at edge 1,  $V_{r1} = 600261.003$

$V_{r1} = V_{Co1} ((10.3), \text{ASCE } 41-17) = knl * V_{Co10}$

$V_{Co10} = 600261.003$

$kn1 = 1$  (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0002017E-011$

$V_u = 1.3927229E-031$

$d = 0.8 * h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$bw = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 600261.003$

$V_{r2} = V_{Co2} ((10.3), \text{ASCE } 41-17) = knl * V_{Co10}$

$V_{Co10} = 600261.003$

$kn1 = 1$  (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0002017E-011$

$V_u = 1.3927229E-031$

$d = 0.8 * h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.3125  
Vs2 = 0.00 is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 847147.582  
bw = 750.00

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

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

Constant Properties

-----  
Knowledge Factor, = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00  
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44  
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 = 694.45  
Existing Column  
Existing material: Steel Strength, fs = 1.25\*fsm = 555.55  
#####

External Height, H = 400.00  
External Width, W = 750.00  
Internal Height, H = 200.00  
Internal Width, W = 550.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 3000.00  
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with lo/lou,min = 0.30  
No FRP Wrapping

-----  
Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -3.9443045E-031$   
EDGE -B-  
Shear Force,  $V_b = 3.9443045E-031$   
BOTH EDGES  
Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 1137.257$   
-Middle:  $A_{sc,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.25537128$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$   
with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.5366E+008$   
 $M_{u1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $M_{u1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.5366E+008$   
 $M_{u2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $M_{u2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5738376E-006$   
 $M_u = 3.5366E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha_1$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.0052143$   
 $\omega_e$  (5.4c) = 0.00183676  
 $\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.12601038$   
 $\alpha_{se1} = 0.12601038$   
 $b_{o1} = 690.00$   
 $h_{o1} = 340.00$   
 $b_{i21} = 1.1834E+006$   
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$   
 $b_{o2} = 542.00$   
 $h_{o2} = 192.00$   
 $b_{i22} = 661256.00$   
 $\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 1.60339$   
Expression ((5.4d), TBDY) for  $\phi_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lo<sub>u,min</sub> = lb/ld = 0.30

su<sub>v</sub> = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fs<sub>yv</sub> = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered characteristic value fs<sub>yv</sub> = fsv/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/ld)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fsv = (fs<sub>jacket</sub>\*As<sub>l,mid,jacket</sub> + fs<sub>mid</sub>\*As<sub>l,mid,core</sub>)/As<sub>l,mid</sub> = 389.0139

with Es<sub>v</sub> = (Es<sub>jacket</sub>\*As<sub>l,mid,jacket</sub> + Es<sub>mid</sub>\*As<sub>l,mid,core</sub>)/As<sub>l,mid</sub> = 200000.00

1 = As<sub>l,ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.04483877

2 = As<sub>l,com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.04483877

v = As<sub>l,mid</sub>/(b\*d)\*(fsv/fc) = 0.01676222

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = As<sub>l,ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.05508907

2 = As<sub>l,com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.05508907

v = As<sub>l,mid</sub>/(b\*d)\*(fsv/fc) = 0.02059413

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.1553529

Mu = MRc (4.14) = 3.5366E+008

u = su (4.1) = 8.5738376E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

u = 8.5738376E-006

Mu = 3.5366E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00118049

N = 11016.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.0052143

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038

ase1 = 0.12601038

bo\_1 = 690.00

ho\_1 = 340.00

bi2\_1 = 1.1834E+006

ase2 = Max(ase1,ase2) = 0.12601038

bo\_2 = 542.00

$$ho_2 = 192.00$$

$$bi2_2 = 661256.00$$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.60339$$

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

$$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.60339$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.0020944$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

No stirrups, ns\_1 = 2.00

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00026808$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

No stirrups, ns\_2 = 2.00

$$h2 = 200.00$$

$$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

No stirrups, ns\_1 = 2.00

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00073723$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

No stirrups, ns\_2 = 2.00

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

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

c = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su1 = 0.4*esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9498$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su2 = 0.4*esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9498$$

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

$$yv = 0.00140044$$

$shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 389.0139$   
 with  $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04483877$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.04483877$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.01676222$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.05508907$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.05508907$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.02059413$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.1553529$   
 $Mu = MRc (4.14) = 3.5366E+008$   
 $u = su (4.1) = 8.5738376E-006$

-----  
 Calculation of ratio  $lb/ld$

-----  
 Inadequate Lap Length with  $lb/ld = 0.30$   
 -----  
 -----

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

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

$u = 8.5738376E-006$   
 $Mu = 3.5366E+008$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max( cu, cc) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.0052143$   
 $we (5.4c) = 0.00183676$   
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.12601038$   
 $ase1 = 0.12601038$

bo\_1 = 690.00  
ho\_1 = 340.00  
bi2\_1 = 1.1834E+006  
ase2 = Max(ase1,ase2) = 0.12601038  
bo\_2 = 542.00  
ho\_2 = 192.00  
bi2\_2 = 661256.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339

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

-----  
psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 200.00

-----  
psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 550.00

-----  
Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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 = 367.9498

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered

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

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s2} = (f_{s,jacket} \cdot A_{s1,com,jacket} + f_{s,core} \cdot A_{s1,com,core})/A_{s1,com} = 367.9498$

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$f_{y_v} = 389.0139$

$s_{u_v} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

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

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

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

considering characteristic value  $f_{s_{y_v}} = f_{s_{y_v}}/1.2$ , 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  $f_{s_{y_v}} = f_{s_{y_v}}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s_{y_v}} = (f_{s,jacket} \cdot A_{s1,mid,jacket} + f_{s,mid} \cdot A_{s1,mid,core})/A_{s1,mid} = 389.0139$

with  $E_{s_{y_v}} = (E_{s,jacket} \cdot A_{s1,mid,jacket} + E_{s,mid} \cdot A_{s1,mid,core})/A_{s1,mid} = 200000.00$

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.04483877$

$2 = A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.04483877$

$v = A_{s1,mid}/(b \cdot d) \cdot (f_{s_{y_v}}/f_c) = 0.01676222$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

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

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

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

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05508907$

$2 = A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05508907$

$v = A_{s1,mid}/(b \cdot d) \cdot (f_{s_{y_v}}/f_c) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u (4.9) = 0.1553529$

$M_u = M_{Rc} (4.14) = 3.5366E+008$

$u = s_u (4.1) = 8.5738376E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $M_{u2}$ -

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.5738376E-006$

$M_u = 3.5366E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} \cdot \text{Max}(\phi_u, cc) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$

$a_{se1} = 0.12601038$

$b_{o\_1} = 690.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 1.1834E+006$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$

$b_{o\_2} = 542.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 661256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$

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

-----  
 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

-----  
 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$

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

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 750.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 550.00$

-----  
 $A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 555.55$

$f_{ce} = 33.00$

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

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.5397$

$fy_1 = 367.9498$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

For calculation of  $e_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_{s1} / 1.2$ , from table 5.1, TBDY.

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

with  $f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 367.9498$

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

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

$$\text{Shear\_factor} = 1.00$$

$$l_0/l_{0u,\min} = l_b/l_{b,\min} = 0.30$$

$$s_u2 = 0.4 \cdot e_{su2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

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

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.

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

$$\text{with } f_{s2} = (f_{s,jacket} \cdot A_{s1,com,jacket} + f_{s,core} \cdot A_{s1,com,core}) / A_{s1,com} = 367.9498$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_0/l_{0u,\min} = l_b/l_d = 0.30$$

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

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

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.

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

$$\text{with } f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 389.0139$$

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

$$1 = A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04483877$$

$$2 = A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483877$$

$$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05508907$$

$$2 = A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508907$$

$$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.1553529$$

$$\mu_u = M_{Rc} (4.14) = 3.5366E+008$$

$$u = s_u (4.1) = 8.5738376E-006$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 923245.821$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 923245.821$

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

$$V_{Col0} = 923245.821$$

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

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

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

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.8236829E-012$

$\nu_u = 3.9443045E-031$

$d = 0.8 \cdot h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{s2} = 78636.768$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $\text{Col2} = 1.00$

$s/d = 0.56818182$

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

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 923245.821$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 923245.821$

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

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.8236829E-012$

$\nu_u = 3.9443045E-031$

$d = 0.8 \cdot h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{s2} = 78636.768$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $\text{Col2} = 1.00$

$s/d = 0.56818182$

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

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$b_w = 400.00$

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

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

Constant Properties

-----  
Knowledge Factor,  $\gamma = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
External Height,  $H = 400.00$   
External Width,  $W = 750.00$   
Internal Height,  $H = 200.00$   
Internal Width,  $W = 550.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties

-----  
Bending Moment,  $M = 2.2170426E-011$   
Shear Force,  $V_2 = 3386.997$   
Shear Force,  $V_3 = 3.7626771E-013$   
Axial Force,  $F = -16097.112$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 1137.257$   
-Middle:  $A_{st,mid} = 402.1239$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,jacket} = 829.3805$   
-Compression:  $A_{sc,com,jacket} = 829.3805$   
-Middle:  $A_{st,mid,jacket} = 402.1239$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,core} = 307.8761$   
-Compression:  $A_{sc,com,core} = 307.8761$   
-Middle:  $A_{st,mid,core} = 0.00$   
Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = u = 0.00198322$   
 $u = y + p = 0.00198322$

-----  
- Calculation of  $y$  -  
-----

$y = (M_y * L_s / 3) / E_{eff} = 0.00198322$  ((4.29), Biskinis Phd)  
 $M_y = 1.2590E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.1741E+013$   
 $factor = 0.30$   
 $A_g = 300000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 28.23333$   
 $N = 16097.112$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 1.0580E+014$

-----  
-----  
Calculation of Yielding Moment  $M_y$   
-----

Calculation of  $y$  and  $M_y$  according to Annex 7 -  
-----

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.3808581E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 296.8915$   
 $d = 357.00$   
 $y = 0.22723402$   
 $A = 0.01019927$   
 $B = 0.00580293$   
with  $p_t = 0.00424746$   
 $p_c = 0.00424746$   
 $p_v = 0.00150186$   
 $N = 16097.112$   
 $b = 750.00$   
 $\rho = 0.12044818$   
 $y_{comp} = 2.7496413E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.22412348$   
 $A = 0.00986014$   
 $B = 0.00560044$   
with  $E_s = 200000.00$

-----  
-----  
Calculation of ratio  $l_b / l_d$   
-----

Inadequate Lap Length with  $l_b / l_d = 0.30$   
-----

- Calculation of  $p$  -  
-----

From table 10-8:  $p = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b / l_d < 1$   
shear control ratio  $V_y E / V_{col} O E = 0.19160863$   
 $d = d_{external} = 357.00$   
 $s = s_{external} = 0.00$   
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00236248$   
jacket:  $s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.0020944$   
 $A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction  
 $h_1 = 400.00$   
 $s_1 = 100.00$   
core:  $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00026808$   
 $A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction  
 $h_2 = 200.00$

$$s2 = 250.00$$

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

For the normalisation  $f_s$  of jacket is used.

$$N_{UD} = 16097.112$$

$$A_g = 300000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 28.23333$$

$$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 529.9972$$

$$f_{yE} = (f_{y\_ext\_Trans\_Reinf} \cdot s1 + f_{y\_int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 542.9506$$

$$\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.00999678$$

$$b = 750.00$$

$$d = 357.00$$

$$f_{cE} = 28.23333$$

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

At local axis: 2

Integration Section: (b)

## Calculation No. 7

column C1, Floor 1

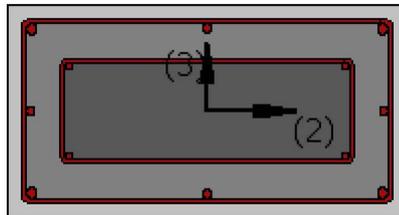
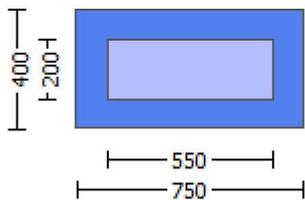
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

-----

Knowledge Factor,  $\phi = 1.00$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of  $\gamma$  for displacement ductility demand,  
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as  
Deformation-Controlled Action (Table C7-1, ASCE 41-17).  
Jacket  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
Existing Column  
Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material: Steel Strength,  $f_s = f_{sm} = 444.44$   
#####  
External Height,  $H = 400.00$   
External Width,  $W = 750.00$   
Internal Height,  $H = 200.00$   
Internal Width,  $W = 550.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
No FRP Wrapping

-----

Stepwise Properties

-----

EDGE -A-  
Bending Moment,  $M_a = 1.1088903E-009$   
Shear Force,  $V_a = -3.7626771E-013$   
EDGE -B-  
Bending Moment,  $M_b = 2.2170426E-011$   
Shear Force,  $V_b = 3.7626771E-013$   
BOTH EDGES  
Axial Force,  $F = -16097.112$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 1137.257$   
-Middle:  $A_{st,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.80$   
-----

-----

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 534028.057$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n I^* V_{CoIO} = 534028.057$   
 $V_{CoI} = 534028.057$   
 $k_n I = 1.00$

displacement\_ductility\_demand = 0.00

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 21.70$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.2170426E-011$

$\nu_u = 3.7626771E-013$

$d = 0.8 \cdot h = 320.00$

$N_u = 16097.112$

$A_g = 300000.00$

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

where:

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

$d = 320.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 742690.493$

$b_w = 750.00$

displacement\_ductility\_demand is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END B -  
for rotation axis 2 and integ. section (b)

From analysis, chord rotation  $\phi = 4.8420344E-021$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00198322$  ((4.29), Biskinis Phd))

$M_y = 1.2590E+008$

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

From table 10.5, ASCE 41\_17:  $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 3.1741E+013$

factor = 0.30

$A_g = 300000.00$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$

$N = 16097.112$

$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 1.0580E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

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

$y_{\text{ten}} = 5.3808581E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b / d)^{2/3}) = 296.8915$

$d = 357.00$

$y = 0.22723402$

$A = 0.01019927$

$B = 0.00580293$

with  $p_t = 0.00424746$

$p_c = 0.00424746$

pv = 0.00150186  
N = 16097.112  
b = 750.00  
" = 0.12044818  
y\_comp = 2.7496413E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.22412348  
A = 0.00986014  
B = 0.00560044  
with Es = 200000.00

-----  
-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$

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

At local axis: 3

Integration Section: (b)

-----

## Calculation No. 8

column C1, Floor 1

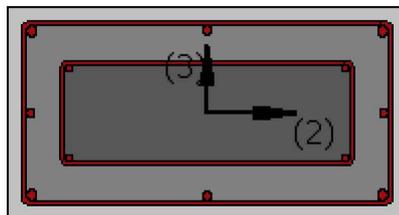
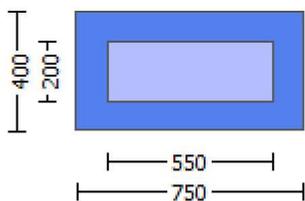
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

Edge: End

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\phi = 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
 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,  $f_s = 1.25 * f_{sm} = 694.45$   
 Existing Column  
 Existing material: Steel Strength,  $f_s = 1.25 * f_{sm} = 555.55$   
 #####  
 External Height,  $H = 400.00$   
 External Width,  $W = 750.00$   
 Internal Height,  $H = 200.00$   
 Internal Width,  $W = 550.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

-----  
 Stepwise Properties  
 -----

At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -1.3927229E-031$   
 EDGE -B-  
 Shear Force,  $V_b = 1.3927229E-031$   
 BOTH EDGES  
 Axial Force,  $F = -11016.808$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $A_{sl,t} = 0.00$   
   -Compression:  $A_{sl,c} = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $A_{sl,ten} = 1137.257$   
   -Compression:  $A_{sl,com} = 1137.257$   
   -Middle:  $A_{sl,mid} = 402.1239$

-----  
 -----  
 Calculation of Shear Capacity ratio,  $V_e/V_r = 0.19160863$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 115015.186$   
 with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.7252E+008$   
 $M_{u1+} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $M_{u1-} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
 direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.7252E+008$$

$M_{u2+} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 1.7214953E-005$$

$$M_u = 1.7252E+008$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$\phi_{we} \text{ (5.4c)} = 0.00183676$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.12601038$$

$$\phi_{ase1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 1.60339$$

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

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 1.60339$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.13667$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

$c = \text{confinement factor} = 1.00$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.5397$   
 $fy1 = 367.9498$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $su1 = 0.4 * esu1\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 367.9498$   
 with  $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 441.5397$   
 $fy2 = 367.9498$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/lb,min = 0.30$   
 $su2 = 0.4 * esu2\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 367.9498$   
 with  $Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 389.0139$   
 with  $Es_v = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.04735912$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.04735912$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, \text{TBDY}) = 33.00$   
 $cc (5A.5, \text{TBDY}) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05619999$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.05619999$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

--->

su (4.9) = 0.16690234  
Mu = MRc (4.14) = 1.7252E+008  
u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Inadequate Lap Length with lb/l<sub>d</sub> = 0.30  
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-----  
Calculation of Mu1-  
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-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 1.7214953E-005  
Mu = 1.7252E+008

-----  
with full section properties:

b = 750.00  
d = 357.00  
d' = 43.00  
v = 0.00124684  
N = 11016.808  
fc = 33.00  
co (5A.5, TBDY) = 0.002  
Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143  
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY: cu = 0.0052143  
we (5.4c) = 0.00183676  
ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038  
ase1 = 0.12601038  
bo\_1 = 690.00  
ho\_1 = 340.00  
bi2\_1 = 1.1834E+006  
ase2 = Max(ase1,ase2) = 0.12601038  
bo\_2 = 542.00  
ho\_2 = 192.00  
bi2\_2 = 661256.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339  
Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

-----  
psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

-----  
Asec = 300000.00  
s1 = 100.00

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } fs_1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9498$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 367.9498$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$su_v = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

$$su_v = 0.4 * esu_{v,nominal} ((5.5), TBDY) = 0.032$$

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

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

For calculation of  $esu_{v,nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $fsy_v = f_{sv}/1.2$ , 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.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$$

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

$$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.04735912$$

$$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.04735912$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / fc) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.05619999$$

$$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.05619999$$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02100943$$

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

--->

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

--->

$$s_u(4.9) = 0.16690234$$

$$\mu_u = M_{Rc}(4.14) = 1.7252E+008$$

$$u = s_u(4.1) = 1.7214953E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{u2+}$

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

$$u = 1.7214953E-005$$

$$\mu_u = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e(5.4c) = 0.00183676$$

$$a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 1.60339$$

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

$$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} \cdot n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} \cdot n_{s\_2} = 100.531$$

No stirrups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 33.00  
 $c_c$  (5A.5, TBDY) = 0.002  
 $c$  = confinement factor = 1.00  
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05619999$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05619999$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

$\mu_u$  (4.9) = 0.16690234  
 $\mu_u = M_{Rc}$  (4.14) = 1.7252E+008  
 $u = \mu_u$  (4.1) = 1.7214953E-005

-----  
 Calculation of ratio  $l_b/l_d$

-----  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----

-----  
 Calculation of  $\mu_{u2}$ -  
 -----

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

$u = 1.7214953E-005$   
 $\mu_u = 1.7252E+008$

-----  
 with full section properties:

$b = 750.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $c_c$  (5A.5, TBDY) = 0.002  
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.0052143$   
 $w_e$  (5.4c) = 0.00183676  
 $a_{se}$  ((5.4d), TBDY) =  $(a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $b_{o,1} = 690.00$   
 $h_{o,1} = 340.00$   
 $b_{i2,1} = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $b_{o,2} = 542.00$   
 $h_{o,2} = 192.00$   
 $b_{i2,2} = 661256.00$   
 $p_{sh,min}*F_{ywe} = \text{Min}(p_{sh,x}*F_{ywe}, p_{sh,y}*F_{ywe}) = 1.60339$   
 Expression ((5.4d), TBDY) for  $p_{sh,min}*F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $p_{sh,x}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 1.60339$   
 $p_{s1}$  (external) =  $(A_{sh1}*h_1/s_1)/A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1}*n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2}$  (internal) =  $(A_{sh2}*h_2/s_2)/A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2}*n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 200.00$

-----  
 $p_{sh,y}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 3.13667$   
 $p_{s1}$  (external) =  $(A_{sh1}*h_1/s_1)/A_{sec} = 0.00392699$

$$\text{Ash1} = \text{Astir}_1 * \text{ns}_1 = 157.0796$$

$$\text{No stirups, ns}_1 = 2.00$$

$$h1 = 750.00$$

$$\text{ps2 (internal)} = (\text{Ash2} * h2 / s2) / \text{Asec} = 0.00073723$$

$$\text{Ash2} = \text{Astir}_2 * \text{ns}_2 = 100.531$$

$$\text{No stirups, ns}_2 = 2.00$$

$$h2 = 550.00$$

---

$$\text{Asec} = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$\text{fywe1} = 694.45$$

$$\text{fywe2} = 555.55$$

$$\text{fce} = 33.00$$

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

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

$$y1 = 0.00140044$$

$$\text{sh1} = 0.0044814$$

$$\text{ft1} = 441.5397$$

$$\text{fy1} = 367.9498$$

$$\text{su1} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$\text{su1} = 0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu1\_nominal} = 0.08,$$

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

$$\text{with fs1} = (\text{fs,jacket} * \text{Asl,ten,jacket} + \text{fs,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 367.9498$$

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

$$y2 = 0.00140044$$

$$\text{sh2} = 0.0044814$$

$$\text{ft2} = 441.5397$$

$$\text{fy2} = 367.9498$$

$$\text{su2} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$\text{su2} = 0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu2\_nominal} = 0.08,$$

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

$$\text{with fs2} = (\text{fs,jacket} * \text{Asl,com,jacket} + \text{fs,core} * \text{Asl,com,core}) / \text{Asl,com} = 367.9498$$

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

$$yv = 0.00140044$$

$$\text{shv} = 0.0044814$$

$$\text{ftv} = 466.8167$$

$$\text{fyv} = 389.0139$$

$$\text{suv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

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

$$\text{with fsv} = (\text{fs,jacket} * \text{Asl,mid,jacket} + \text{fs,mid} * \text{Asl,mid,core}) / \text{Asl,mid} = 389.0139$$

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

$$1 = \text{Asl,ten} / (\text{b} * \text{d}) * (\text{fs1} / \text{fc}) = 0.04735912$$

$$2 = \text{Asl,com} / (\text{b} * \text{d}) * (\text{fs2} / \text{fc}) = 0.04735912$$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05619999$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05619999$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16690234$   
 $Mu = MRc (4.14) = 1.7252E+008$   
 $u = su (4.1) = 1.7214953E-005$

-----  
 Calculation of ratio  $l_b/l_d$

-----  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----  
 -----

-----  
 Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 600261.003$   
 -----

-----  
 Calculation of Shear Strength at edge 1,  $V_{r1} = 600261.003$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$   
 $V_{Col0} = 600261.003$   
 $k_{nl} = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$   
 $Mu = 1.0002017E-011$   
 $Vu = 1.3927229E-031$   
 $d = 0.8 * h = 320.00$   
 $Nu = 11016.808$   
 $Ag = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:  
 $V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$

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

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

$d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.44$   
 $s = 250.00$

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

$V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$   
 $bw = 750.00$

-----  
Calculation of Shear Strength at edge 2, Vr2 = 600261.003

Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

VCol0 = 600261.003

knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 28.23333, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.0002017E-011

Vu = 1.3927229E-031

d = 0.8\*h = 320.00

Nu = 11016.808

Ag = 300000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914

where:

Vs1 = 279254.914 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 444.44

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 847147.582

bw = 750.00

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

Constant Properties

-----  
Knowledge Factor, = 1.00

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

Consequently:

Jacket

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

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

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

Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44

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,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2

EDGE -A-

Shear Force,  $V_a = -3.9443045E-031$

EDGE -B-

Shear Force,  $V_b = 3.9443045E-031$

BOTH EDGES

Axial Force,  $F = -11016.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t, \text{ten}} = 1137.257$

-Compression:  $As_{c, \text{com}} = 1137.257$

-Middle:  $As_{c, \text{mid}} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.25537128$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$

with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 3.5366E+008$   
 $Mu_{1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 3.5366E+008$   
 $Mu_{2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $Mu_{2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $Mu_{1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5738376E-006$

$Mu = 3.5366E+008$

-----  
with full section properties:

b = 400.00  
d = 707.00  
d' = 43.00  
v = 0.00118049  
N = 11016.808  
fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.0052143$

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) =  $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.12601038$

ase1 = 0.12601038

bo\_1 = 690.00

ho\_1 = 340.00

bi2\_1 = 1.1834E+006

ase2 =  $\text{Max}(ase1, ase2) = 0.12601038$

bo\_2 = 542.00

ho\_2 = 192.00

bi2\_2 = 661256.00

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.60339$

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

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.60339$

ps1 (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.0020944$

Ash1 =  $A_{stir\_1} * ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

h1 = 400.00

ps2 (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00026808$

Ash2 =  $A_{stir\_2} * ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

h2 = 200.00

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.13667$

ps1 (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$

Ash1 =  $A_{stir\_1} * ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

h1 = 750.00

ps2 (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00073723$

Ash2 =  $A_{stir\_2} * ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

h2 = 550.00

-----  
Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

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

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

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

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

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

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

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{\text{ou,min}} = lb/lb_{\text{min}} = 0.30$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

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.

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl_{\text{com,jacket}} + fs_{\text{core}} \cdot Asl_{\text{com,core}}) / Asl_{\text{com}} = 367.9498$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl_{\text{com,jacket}} + Es_{\text{core}} \cdot Asl_{\text{com,core}}) / Asl_{\text{com}} = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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.

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl_{\text{mid,jacket}} + fs_{\text{mid}} \cdot Asl_{\text{mid,core}}) / Asl_{\text{mid}} = 389.0139$$

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

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs1 / fc) = 0.04483877$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs2 / fc) = 0.04483877$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 33.00$$

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

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

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs1 / fc) = 0.05508907$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs2 / fc) = 0.05508907$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$su (4.9) = 0.1553529$$

$$Mu = MRc (4.14) = 3.5366E+008$$

$$u = su (4.1) = 8.5738376E-006$$

-----  
Calculation of ratio  $lb/ld$

-----  
Inadequate Lap Length with  $lb/ld = 0.30$   
-----  
-----  
-----

-----  
Calculation of  $Mu1$ -  
-----  
-----  
-----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$\mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$w_e(5.4c) = 0.00183676$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

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

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

with  $fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 367.9498$

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 441.5397$

$fy2 = 367.9498$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

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

$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

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

with  $fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9498$

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

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 466.8167$

$fyv = 389.0139$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

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

$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

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

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

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

with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$

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

$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.04483877$

$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.04483877$

$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01676222$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

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

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

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

$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.05508907$

$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05508907$

$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.1553529$

$Mu = MRc (4.14) = 3.5366E+008$

$u = su (4.1) = 8.5738376E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Mu2+

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.5738376E-006$$

$$Mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e \text{ (5.4c)} = 0.00183676$$

$$\text{ase ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

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

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$$s_u1 = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$$

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

For calculation of  $e_{su1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.

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

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9498$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$s_u2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 367.9498$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_uv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

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

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04483877$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04483877$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05508907$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05508907$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.1553529$$

$$\mu_u = M_{Rc} (4.14) = 3.5366E+008$$

$$u = s_u (4.1) = 8.5738376E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.5738376E-006$$

$$\mu_2 = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_2: \mu_2^* = \text{shear\_factor} * \text{Max}(\mu_2, c_0) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_2 = 0.0052143$$

$$\mu_2 \text{ (5.4c)} = 0.00183676$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

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

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

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

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

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 441.5397  
fy1 = 367.9498  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044  
sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044  
shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04483877

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04483877

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01676222

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05508907

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05508907

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02059413

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

su (4.9) = 0.1553529  
Mu = MRc (4.14) = 3.5366E+008  
u = su (4.1) = 8.5738376E-006

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Inadequate Lap Length with lb/l<sub>d</sub> = 0.30  
-----  
-----  
-----

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 923245.821  
-----

Calculation of Shear Strength at edge 1, Vr1 = 923245.821  
Vr1 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 923245.821  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 28.23333, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 6.8236829E-012  
Vu = 3.9443045E-031  
d = 0.8\*h = 600.00  
Nu = 11016.808  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 602239.733  
where:  
Vs1 = 523602.964 is calculated for jacket, with:  
d = 600.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.16666667  
Vs2 = 78636.768 is calculated for core, with:  
d = 440.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
Vs2 is multiplied by Col2 = 1.00  
s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 847147.582  
bw = 400.00  
-----

-----  
Calculation of Shear Strength at edge 2, Vr2 = 923245.821  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 923245.821  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 28.23333, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 6.8236829E-012  
Vu = 3.9443045E-031  
d = 0.8\*h = 600.00

Nu = 11016.808  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$   
where:  
 $V_{s1} = 523602.964$  is calculated for jacket, with:  
d = 600.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
 $V_{s1}$  is multiplied by Col1 = 1.00  
s/d = 0.16666667  
 $V_{s2} = 78636.768$  is calculated for core, with:  
d = 440.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
 $V_{s2}$  is multiplied by Col2 = 1.00  
s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$   
bw = 400.00

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

-----  
Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (b)  
Section Type: rcjrs

#### Constant Properties

-----  
Knowledge Factor, = 1.00  
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
External Height, H = 400.00  
External Width, W = 750.00  
Internal Height, H = 200.00  
Internal Width, W = 550.00  
Cover Thickness, c = 25.00  
Element Length, L = 3000.00  
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

-----

Bending Moment,  $M = 1.5146E+006$   
 Shear Force,  $V2 = 3386.997$   
 Shear Force,  $V3 = 3.7626771E-013$   
 Axial Force,  $F = -16097.112$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{,ten} = 1137.257$   
   -Compression:  $As_{,com} = 1137.257$   
   -Middle:  $As_{,mid} = 402.1239$   
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{,ten,jacket} = 829.3805$   
   -Compression:  $As_{,com,jacket} = 829.3805$   
   -Middle:  $As_{,mid,jacket} = 402.1239$   
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{,ten,core} = 307.8761$   
   -Compression:  $As_{,com,core} = 307.8761$   
   -Middle:  $As_{,mid,core} = 0.00$   
 Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = \phi u = 0.00034314$   
 $u = y + p = 0.00034314$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00034314$  ((4.29), Biskinis Phd)  
 $M_y = 2.5076E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) =  $447.1746$   
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.0893E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
 Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 28.23333$   
 $N = 16097.112$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.6310E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.6761016E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 296.8915$   
 $d = 707.00$   
 $y = 0.21540464$   
 $A = 0.00965649$   
 $B = 0.00521193$   
 with  $pt = 0.00402142$   
 $pc = 0.00402142$   
 $p_v = 0.00142194$   
 $N = 16097.112$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.4664753E-005$   
 with  $fc = 33.00$   
 $E_c = 26999.444$   
 $y = 0.21219612$   
 $A = 0.00933541$   
 $B = 0.00502021$   
 with  $E_s = 200000.00$

-----  
Calculation of ratio  $l_b/l_d$   
-----

Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----

- Calculation of  $\rho$  -  
-----

From table 10-8:  $\rho = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$   
shear control ratio  $V_{yE}/V_{ColOE} = 0.25537128$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2*tf/bw*(ffe/fs) = 0.00466422$

jacket:  $s_1 = A_{v1}*h_1/(s_1*Ag) = 0.00392699$

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

$h_1 = 750.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2}*h_2/(s_2*Ag) = 0.00073723$

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

$h_2 = 550.00$

$s_2 = 250.00$

The term  $2*tf/bw*(ffe/fs)$  is implemented to account for FRP contribution

where  $f = 2*tf/bw$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $ffe/fs$  normalises  $f$  to steel strength

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

For the normalisation  $f_s$  of jacket is used.

$NUD = 16097.112$

$Ag = 300000.00$

$f_{cE} = (f_{c\_jacket}*Area\_jacket + f_{c\_core}*Area\_core)/section\_area = 28.23333$

$f_{yE} = (f_{y\_ext\_Long\_Reinf}*Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf}*Area\_int\_Long\_Reinf)/Area\_Tot\_Long\_Rein = 529.9972$

$f_{yE} = (f_{y\_ext\_Trans\_Reinf}*s_1 + f_{y\_int\_Trans\_Reinf}*s_2)/(s_1 + s_2) = 537.9964$

$\rho_l = Area\_Tot\_Long\_Rein/(b*d) = 0.00946477$

$b = 400.00$

$d = 707.00$

$f_{cE} = 28.23333$   
-----

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

At local axis: 3

Integration Section: (b)  
-----

**Calculation No. 9**

column C1, Floor 1

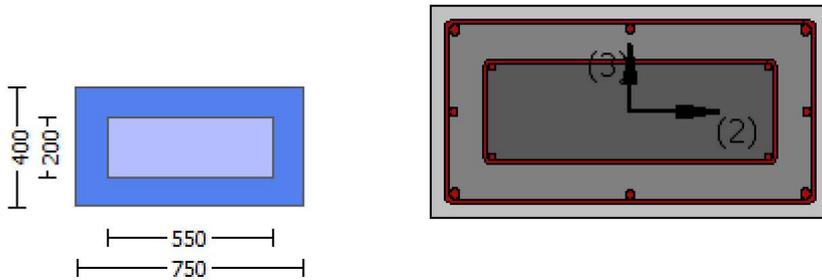
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

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

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

Existing material: Steel Strength,  $f_s = f_{sm} = 444.44$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

EDGE -A-  
Bending Moment,  $M_a = -9.7390E+006$   
Shear Force,  $V_a = -2823.172$   
EDGE -B-  
Bending Moment,  $M_b = 1.2625E+006$   
Shear Force,  $V_b = 2823.172$   
BOTH EDGES  
Axial Force,  $F = -15251.406$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sl,com} = 1137.257$   
-Middle:  $A_{sl,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = *V_n = 683279.382$   
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col0} = 683279.382$   
 $V_{Col} = 683279.382$   
 $knl = 1.00$   
 $displacement\_ductility\_demand = 0.02147243$

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

-----  
= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 21.70$ , but  $f_c'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $M_u = 9.7390E+006$   
 $V_u = 2823.172$   
 $d = 0.8 * h = 600.00$   
 $N_u = 15251.406$   
 $A_g = 300000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 542012.697$   
where:  
 $V_{s1} = 471238.898$  is calculated for jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s2} = 70773.799$  is calculated for core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 742690.493$   
 $bw = 400.00$

displacement\_ductility\_demand is calculated as  $\phi / y$

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

From analysis, chord rotation =  $5.6781442E-005$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00264439 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 2.5050E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3449.669$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.0893E+014$$

$$\text{factor} = 0.30$$

$$A_g = 300000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$$

$$N = 15251.406$$

$$E_c * I_g = E_c_{\text{jacket}} * I_{g_{\text{jacket}}} + E_c_{\text{core}} * I_{g_{\text{core}}} = 3.6310E+014$$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi / y$  and  $M_y$  according to Annex 7 -

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

$$y_{\text{ten}} = 2.6754055E-006$$

$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 296.8915$$

$$d = 707.00$$

$$y = 0.21520049$$

$$A = 0.00964642$$

$$B = 0.00520186$$

$$\text{with } p_t = 0.00402142$$

$$p_c = 0.00402142$$

$$p_v = 0.00142194$$

$$N = 15251.406$$

$$b = 400.00$$

$$" = 0.06082037$$

$$y_{\text{comp}} = 1.4667378E-005$$

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

$$E_c = 26999.444$$

$$y = 0.21215815$$

$$A = 0.0093422$$

$$B = 0.00502021$$

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

Calculation of ratio  $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

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

At local axis: 2

Integration Section: (a)

**Calculation No. 10**

column C1, Floor 1

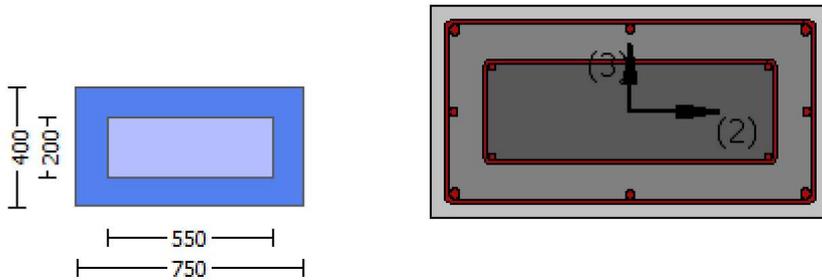
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\phi$ )

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

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,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -1.3927229E-031$   
EDGE -B-  
Shear Force,  $V_b = 1.3927229E-031$   
BOTH EDGES  
Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1137.257$   
-Compression:  $As_{c,com} = 1137.257$   
-Middle:  $As_{c,mid} = 402.1239$

-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19160863$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 115015.186$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.7252E+008$   
 $\mu_{u1+} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $\mu_{u1-} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 1.7252E+008$   
 $\mu_{u2+} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $\mu_{u2-} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $\mu_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 1.7214953E-005$   
 $\mu_u = 1.7252E+008$

-----  
with full section properties:

$b = 750.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\text{co (5A.5, TBDY)} = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \text{cc}) = 0.0052143$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.0052143$   
 $w_e$  (5.4c) =  $0.00183676$   
 $a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $b_{o\_1} = 690.00$   
 $h_{o\_1} = 340.00$   
 $b_{i2\_1} = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$

$$bo\_2 = 542.00$$

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.60339$$

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

$$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.60339$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.0020944$$

$$Ash1 = Astir\_1*ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00026808$$

$$Ash2 = Astir\_2*ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 200.00$$

$$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$

$$Ash1 = Astir\_1*ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00073723$$

$$Ash2 = Astir\_2*ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

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

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su1 = 0.4*esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9498$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su2 = 0.4*esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9498$$

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

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30  
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Calculation of Mu1-  
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-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 1.7214953E-005

Mu = 1.7252E+008

-----  
with full section properties:

b = 750.00

d = 357.00

d' = 43.00

v = 0.00124684

N = 11016.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.0052143

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038

ase1 = 0.12601038  
bo\_1 = 690.00  
ho\_1 = 340.00  
bi2\_1 = 1.1834E+006  
ase2 = Max(ase1,ase2) = 0.12601038  
bo\_2 = 542.00  
ho\_2 = 192.00  
bi2\_2 = 661256.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339

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

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00  
s1 = 100.00  
s2 = 250.00

fywe1 = 694.45  
fywe2 = 555.55  
fce = 33.00

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

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 441.5397  
fy1 = 367.9498  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = (fsjacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

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

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 441.5397  
fy2 = 367.9498  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of  $es_{u2\_nominal}$  and  $y_2$ ,  $sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

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

with  $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 367.9498$

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$s_{uv} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.30$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.032$

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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 389.0139$

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04735912$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04735912$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01770442$

and confined core properties:

$b = 690.00$

$d = 327.00$

$d' = 13.00$

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

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

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05619999$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05619999$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u (4.9) = 0.16690234$

$\mu_u = MR_c (4.14) = 1.7252E+008$

$u = s_u (4.1) = 1.7214953E-005$

-----  
Calculation of ratio  $lb/ld$

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Inadequate Lap Length with  $lb/ld = 0.30$   
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Calculation of  $\mu_{u2+}$   
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Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7214953E-005$

$\mu_u = 1.7252E+008$   
-----

with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$

$a_{se1} = 0.12601038$

$b_{o\_1} = 690.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 1.1834E+006$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$

$b_{o\_2} = 542.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 661256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$

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

-----  
 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

-----  
 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$

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

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 750.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 550.00$

-----  
 $A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 555.55$

$f_{ce} = 33.00$

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

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.5397$

$fy_1 = 367.9498$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 367.9498$

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

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

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30

-----  
Calculation of Mu2-

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

u = 1.7214953E-005

Mu = 1.7252E+008

-----  
with full section properties:

b = 750.00

d = 357.00

$d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.0052143$   
 $w_e (5.4c) = 0.00183676$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase2 = Max(ase1, ase2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$   
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.60339$   
 Expression ((5.4d), TBDY) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.60339$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.0020944$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00026808$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 200.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.13667$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00073723$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 550.00$

$A_{sec} = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 555.55$   
 $f_{ce} = 33.00$

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

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.5397$   
 $fy1 = 367.9498$   
 $su1 = 0.00512$

using (30) in Bisikinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/d = 0.30$

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

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

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

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

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$

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

$y2 = 0.00140044$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 0.30$$

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

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

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

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

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9498$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$$

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.04735912$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.04735912$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.05619999$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05619999$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.16690234$$

$$Mu = MRc (4.14) = 1.7252E+008$$

$$u = su (4.1) = 1.7214953E-005$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 600261.003$

Calculation of Shear Strength at edge 1,  $Vr1 = 600261.003$

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$$

$$VColO = 600261.003$$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0002017E-011$

$\nu_u = 1.3927229E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$b_w = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 600261.003$

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

$V_{Col0} = 600261.003$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0002017E-011$

$\nu_u = 1.3927229E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

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

s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 847147.582  
bw = 750.00

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

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

Constant Properties

-----  
Knowledge Factor, = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00  
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44  
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 = 694.45  
Existing Column  
Existing material: Steel Strength, fs = 1.25\*fsm = 555.55  
#####  
External Height, H = 400.00  
External Width, W = 750.00  
Internal Height, H = 200.00  
Internal Width, W = 550.00  
Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.00  
Element Length, L = 3000.00  
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with lo/lo,min = 0.30  
No FRP Wrapping

-----  
-----  
Stepwise Properties

-----  
-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = -3.9443045E-031  
EDGE -B-  
Shear Force, Vb = 3.9443045E-031  
BOTH EDGES  
Axial Force, F = -11016.808  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: Aslt = 0.00

-Compression:  $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{l,com} = 1137.257$

-Middle:  $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.25537128$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.5366E+008$

$Mu_{1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.5366E+008$

$Mu_{2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5738376E-006$

$M_u = 3.5366E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.0052143$

$\phi_{ue}$  (5.4c) = 0.00183676

$\phi_{ase}$  ((5.4d), TBDY) =  $(\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.12601038$

$\phi_{ase1} = 0.12601038$

$b_{o,1} = 690.00$

$h_{o,1} = 340.00$

$\phi_{bi,2,1} = 1.1834E+006$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.12601038$

$b_{o,2} = 542.00$

$h_{o,2} = 192.00$

$\phi_{bi,2,2} = 661256.00$

$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 1.60339$

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

$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 1.60339$

$\phi_{ps1}$  (external) =  $(\phi_{Ash1} * h_1 / s_1) / A_{sec} = 0.0020944$

$\phi_{Ash1} = \phi_{Astir,1} * n_{s,1} = 157.0796$

No stirrups,  $n_{s,1} = 2.00$

$h_1 = 400.00$

$\phi_{ps2}$  (internal) =  $(\phi_{Ash2} * h_2 / s_2) / A_{sec} = 0.00026808$

$\phi_{Ash2} = \phi_{Astir,2} * n_{s,2} = 100.531$

No stirrups,  $n_{s,2} = 2.00$

$h_2 = 200.00$

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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 = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.04483877$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.04483877$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.05508907$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.05508907$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.1553529$$

$$Mu = MRc (4.14) = 3.5366E+008$$

$$u = su (4.1) = 8.5738376E-006$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu1$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$Mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.0052143$

$$we (5.4c) = 0.00183676$$

$$ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.12601038$$

$$ase1 = 0.12601038$$

$$bo_1 = 690.00$$

$$ho_1 = 340.00$$

$$bi2_1 = 1.1834E+006$$

$$ase2 = \text{Max}(ase1,ase2) = 0.12601038$$

$$bo_2 = 542.00$$

$$ho_2 = 192.00$$

$$bi2_2 = 661256.00$$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.60339$$

Expression ((5.4d), TBDY) for  $psh,min*Fywe$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.60339$$

$$ps1 (\text{external}) = (Ash1*h1/s1)/Asec = 0.0020944$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

$$\text{No stirrups, } ns_1 = 2.00$$

h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

-----  
psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

-----  
Asec = 300000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 555.55  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 441.5397  
fy1 = 367.9498  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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 = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 441.5397  
fy2 = 367.9498  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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 = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 389.0139$

with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04483877$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483877$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01676222$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc}$  (5A.2, TBDY) = 33.00

$cc$  (5A.5, TBDY) = 0.002

$c$  = confinement factor = 1.00

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05508907$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508907$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su$  (4.9) = 0.1553529

$Mu = MRc$  (4.14) = 3.5366E+008

$u = su$  (4.1) = 8.5738376E-006

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----

-----  
Calculation of  $Mu_{2+}$   
-----  
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.5738376E-006$

$Mu = 3.5366E+008$   
-----

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.12601038$

$ase_1 = 0.12601038$

$bo_1 = 690.00$

$ho_1 = 340.00$

$bi_{2,1} = 1.1834E+006$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$

$bo_2 = 542.00$

$ho_2 = 192.00$

$bi_{2,2} = 661256.00$

$psh_{,min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 1.60339$

Expression ((5.4d), TBDY) for  $psh_{,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lo<sub>u,min</sub> = lb/ld = 0.30

su<sub>v</sub> = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fs<sub>yv</sub> = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered characteristic value fs<sub>yv</sub> = fsv/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/ld)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fsv = (fs<sub>jacket</sub>\*As<sub>l,mid,jacket</sub> + fs<sub>mid</sub>\*As<sub>l,mid,core</sub>)/As<sub>l,mid</sub> = 389.0139

with Es<sub>v</sub> = (Es<sub>jacket</sub>\*As<sub>l,mid,jacket</sub> + Es<sub>mid</sub>\*As<sub>l,mid,core</sub>)/As<sub>l,mid</sub> = 200000.00

1 = As<sub>l,ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.04483877

2 = As<sub>l,com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.04483877

v = As<sub>l,mid</sub>/(b\*d)\*(fsv/fc) = 0.01676222

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = As<sub>l,ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.05508907

2 = As<sub>l,com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.05508907

v = As<sub>l,mid</sub>/(b\*d)\*(fsv/fc) = 0.02059413

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.1553529

Mu = MRc (4.14) = 3.5366E+008

u = su (4.1) = 8.5738376E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu<sub>2</sub>-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.5738376E-006

Mu = 3.5366E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00118049

N = 11016.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.0052143

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038

ase1 = 0.12601038

bo<sub>1</sub> = 690.00

ho<sub>1</sub> = 340.00

bi<sub>2,1</sub> = 1.1834E+006

ase2 = Max(ase1,ase2) = 0.12601038

bo<sub>2</sub> = 542.00

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.60339$$

Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.60339$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.0020944$$

$$Ash1 = Astir\_1*ns\_1 = 157.0796$$

No stirrups, ns\_1 = 2.00

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00026808$$

$$Ash2 = Astir\_2*ns\_2 = 100.531$$

No stirrups, ns\_2 = 2.00

$$h2 = 200.00$$

$$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$

$$Ash1 = Astir\_1*ns\_1 = 157.0796$$

No stirrups, ns\_1 = 2.00

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00073723$$

$$Ash2 = Astir\_2*ns\_2 = 100.531$$

No stirrups, ns\_2 = 2.00

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$su1 = 0.4*esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9498$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9498$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.00140044$$

$shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 389.0139$   
 with  $Esv = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.04483877$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.04483877$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05508907$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.05508907$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < vs,y2$  - LHS eq.(4.5) is satisfied

---

$su (4.9) = 0.1553529$   
 $Mu = MRc (4.14) = 3.5366E+008$   
 $u = su (4.1) = 8.5738376E-006$

-----  
 Calculation of ratio  $lb/ld$

-----  
 Inadequate Lap Length with  $lb/ld = 0.30$   
 -----  
 -----  
 -----

-----  
 Calculation of Shear Strength  $Vr = Min(Vr1, Vr2) = 923245.821$   
 -----

-----  
 Calculation of Shear Strength at edge 1,  $Vr1 = 923245.821$

$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$

$VColO = 923245.821$

$knl = 1$  (zero step-static loading)

-----  
 NOTE: In expression (10-3) ' $Vs = Av * fy * d / s$ ' is replaced by ' $Vs + f * Vf$ '  
 where  $Vf$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $= 1$  (normal-weight concrete)

Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 28.23333$ , but  $fc'^{0.5} <=$   
 $8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 6.8236829E-012$

$Vu = 3.9443045E-031$

$d = 0.8 * h = 600.00$

$Nu = 11016.808$

$Ag = 300000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 602239.733$

where:

Vs1 = 523602.964 is calculated for jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.16666667$$

Vs2 = 78636.768 is calculated for core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.44$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.56818182$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 847147.582

$$b_w = 400.00$$

Calculation of Shear Strength at edge 2, Vr2 = 923245.821

Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

$$V_{Col0} = 923245.821$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*VF' where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 28.23333$ , but  $f_c'^{0.5} <= 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/d = 2.00$$

$$M_u = 6.8236829E-012$$

$$V_u = 3.9443045E-031$$

$$d = 0.8 * h = 600.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 602239.733

where:

Vs1 = 523602.964 is calculated for jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.16666667$$

Vs2 = 78636.768 is calculated for core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.44$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.56818182$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 847147.582

$$b_w = 400.00$$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

## Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$

No FRP Wrapping

## Stepwise Properties

Bending Moment,  $M = 9.2596107E-010$

Shear Force,  $V_2 = -2823.172$

Shear Force,  $V_3 = -3.1363135E-013$

Axial Force,  $F = -15251.406$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 0.00$

-Compression:  $A_{sl,c} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1137.257$

-Compression:  $A_{sl,com} = 1137.257$

-Middle:  $A_{sl,mid} = 402.1239$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten,jacket} = 829.3805$

-Compression:  $A_{sl,com,jacket} = 829.3805$

-Middle:  $A_{sl,mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten,core} = 307.8761$

-Compression:  $A_{sl,com,core} = 307.8761$

-Middle:  $A_{sl,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = \gamma \cdot u = 0.01790598$

$u = \gamma \cdot p = 0.01790598$

- Calculation of  $\gamma$  -

$\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.00198111$  ((4.29), Biskinis Phd))

$M_y = 1.2577E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.1741E+013$

factor = 0.30

$A_g = 300000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 28.23333$

$N = 15251.406$

$E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 1.0580E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 5.3794571E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 296.8915$

$d = 357.00$

$y = 0.22703277$

$A = 0.01018864$

$B = 0.00579229$

with  $pt = 0.00424746$

$pc = 0.00424746$

$pv = 0.00150186$

$N = 15251.406$

$b = 750.00$

$\rho = 0.12044818$

$y_{comp} = 2.7501333E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.22408338$

$A = 0.00986732$

$B = 0.00560044$

with  $E_s = 200000.00$

Calculation of ratio  $l_b / d$

Inadequate Lap Length with  $l_b / d = 0.30$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.01592487$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b / d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.19160863$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00236248$

jacket:  $s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.0020944$

$A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 400.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00026808$

$A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 200.00$

$s_2 = 250.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation  $f_s$  of jacket is used.

$N_{UD} = 15251.406$

$A_g = 300000.00$

$f_c E = (f_c_{jacket} * Area_{jacket} + f_c_{core} * Area_{core}) / section\_area = 28.23333$

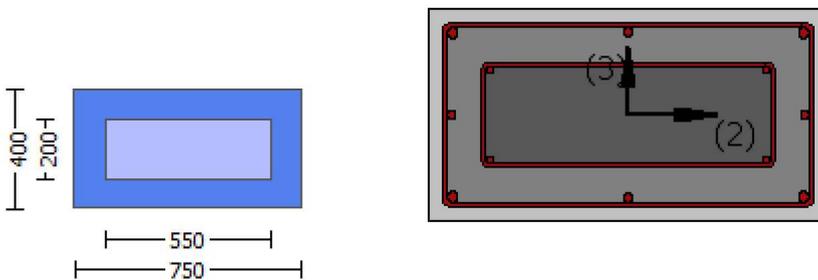
$f_y E = (f_y_{ext\_Long\_Reinf} * Area_{ext\_Long\_Reinf} + f_y_{int\_Long\_Reinf} * Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 529.9972$

$f_{tE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 542.9506$   
 $p_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.00999678$   
 $b = 750.00$   
 $d = 357.00$   
 $f_{cE} = 28.23333$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 2  
Integration Section: (a)

## Calculation No. 11

column C1, Floor 1  
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity  $V_{Rd}$   
Edge: Start  
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (a)  
Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material: Steel Strength,  $f_s = f_{sm} = 555.56$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material: Steel Strength,  $f_s = f_{sm} = 444.44$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

-----  
Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 9.2596107E-010$

Shear Force,  $V_a = -3.1363135E-013$

EDGE -B-

Bending Moment,  $M_b = 1.6814758E-011$

Shear Force,  $V_b = 3.1363135E-013$

BOTH EDGES

Axial Force,  $F = -15251.406$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-Compression:  $A_{slc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1137.257$

-Compression:  $A_{sl,com} = 1137.257$

-Middle:  $A_{sl,mid} = 402.1239$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 533860.781$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 533860.781$

$V_{CoI} = 533860.781$

$k_n = 1.00$

displacement\_ductility\_demand = 0.00

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + \phi \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 21.70$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / V_d = 2.00$

$M_u = 9.2596107E-010$

$V_u = 3.1363135E-013$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 15251.406$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 251327.412$   
 where:  
 $V_{s1} = 251327.412$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 742690.493$   
 $b_w = 750.00$

displacement ductility demand is calculated as  $\delta / y$

- Calculation of  $\delta / y$  for END A -  
for rotation axis 2 and integ. section (a)

From analysis, chord rotation  $\theta = 1.5278639E-020$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00198111$  ((4.29), Biskinis Phd)  
 $M_y = 1.2577E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 3.1741E+013$   
 $factor = 0.30$   
 $A_g = 300000.00$   
 Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot Area_{jacket} + f'_{c\_core} \cdot Area_{core}) / Area_{section} = 28.23333$   
 $N = 15251.406$   
 $E_c \cdot I_g = E_{c\_jacket} \cdot I_{g\_jacket} + E_{c\_core} \cdot I_{g\_core} = 1.0580E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\delta / y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.3794571E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/d)^{2/3}) = 296.8915$   
 $d = 357.00$   
 $y = 0.22703277$   
 $A = 0.01018864$   
 $B = 0.00579229$   
 with  $pt = 0.00424746$   
 $pc = 0.00424746$   
 $pv = 0.00150186$   
 $N = 15251.406$   
 $b = 750.00$   
 $\theta = 0.12044818$   
 $y_{comp} = 2.7501333E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.22408338$   
 $A = 0.00986732$   
 $B = 0.00560044$

with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

## Calculation No. 12

column C1, Floor 1

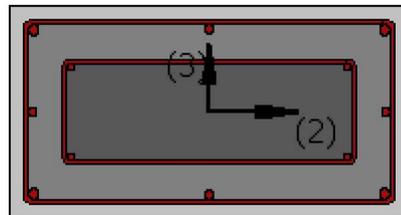
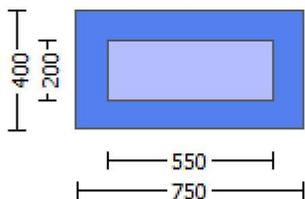
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

```

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$ 
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$ 
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,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$ 
#####
External Height,  $H = 400.00$ 
External Width,  $W = 750.00$ 
Internal Height,  $H = 200.00$ 
Internal Width,  $W = 550.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.00
Element Length,  $L = 3000.00$ 
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$ 
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = -1.3927229E-031$ 
EDGE -B-
Shear Force,  $V_b = 1.3927229E-031$ 
BOTH EDGES
Axial Force,  $F = -11016.808$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension:  $As_t = 0.00$ 
  -Compression:  $As_c = 2676.637$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension:  $As_{t,ten} = 1137.257$ 
  -Compression:  $As_{c,com} = 1137.257$ 
  -Middle:  $As_{c,mid} = 402.1239$ 
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19160863$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 115015.186$ 
with
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.7252E+008$ 
 $\mu_{u1+} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 1.7252E+008$ 
 $\mu_{u2+} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
-----

Calculation of  $\mu_{u1+}$ 
-----

```

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

$$Mu = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0052143$$

$$\phi_{we}(5.4c) = 0.00183676$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 200.00$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.13667$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.002$$

$c$  = confinement factor = 1.00

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{ou,min} = l_b / d = 0.30$$

$$su_1 = 0.4 * esu_{1\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{1\_nominal} = 0.08$ ,

For calculation of  $esu_{1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 367.9498$$

$$\text{with } Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou_{min} = lb/lb_{min} = 0.30$$

$$su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,

For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9498$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou_{min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$$

$$\text{with } Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.04735912$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04735912$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05619999$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05619999$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16690234$$

$$Mu = MRc (4.14) = 1.7252E+008$$

$$u = su (4.1) = 1.7214953E-005$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.7214953E-005$$

$$Mu = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, cc) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.0052143$$

$$w_e \text{ (5.4c)} = 0.00183676$$

$$ase \text{ ((5.4d), TBDY)} = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.12601038$$

$$ase1 = 0.12601038$$

$$bo\_1 = 690.00$$

$$ho\_1 = 340.00$$

$$bi2\_1 = 1.1834E+006$$

$$ase2 = \text{Max}(ase1, ase2) = 0.12601038$$

$$bo\_2 = 542.00$$

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.60339$$

$$ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 200.00$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.13667$$

$$ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.7214953E-005$$

$$\mu_{2+} = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_{2+}: \mu_{2+}^* = \text{shear\_factor} * \text{Max}(\mu_{2+}, c_o) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_{2+} = 0.0052143$$

$$\mu_{2+} \text{ (5.4c)} = 0.00183676$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.12601038$$

$$\text{ase}_1 = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $\text{psh}_{\min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 1.60339$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 3.13667$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$c = \text{confinement factor} = 1.00$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.5397$   
 $fy1 = 367.9498$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $su1 = 0.4 * esu1\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 367.9498$   
 with  $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 441.5397$   
 $fy2 = 367.9498$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/lb,min = 0.30$   
 $su2 = 0.4 * esu2\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 367.9498$   
 with  $Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 389.0139$   
 with  $Es_v = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.04735912$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.04735912$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, \text{TBDY}) = 33.00$   
 $cc (5A.5, \text{TBDY}) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05619999$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.05619999$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16690234  
Mu = MRc (4.14) = 1.7252E+008  
u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Inadequate Lap Length with lb/l<sub>d</sub> = 0.30  
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-----  
Calculation of Mu<sub>2</sub>-  
-----

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 1.7214953E-005  
Mu = 1.7252E+008  
-----

with full section properties:

b = 750.00  
d = 357.00  
d' = 43.00  
v = 0.00124684  
N = 11016.808  
f<sub>c</sub> = 33.00  
co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143  
The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.0052143  
we (5.4c) = 0.00183676  
ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038  
ase1 = 0.12601038  
bo\_1 = 690.00  
ho\_1 = 340.00  
bi2\_1 = 1.1834E+006  
ase2 = Max(ase1,ase2) = 0.12601038  
bo\_2 = 542.00  
ho\_2 = 192.00  
bi2\_2 = 661256.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339  
Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00  
-----

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00  
-----

Asec = 300000.00  
s1 = 100.00

$s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 555.55$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 441.5397$   
 $fy_1 = 367.9498$   
 $su_1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 0.30$   
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 367.9498$   
 with  $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 441.5397$   
 $fy_2 = 367.9498$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.30$   
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 367.9498$   
 with  $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 0.30$   
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 389.0139$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.04735912$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.04735912$   
 $v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$   
 $cc \text{ (5A.5, TBDY)} = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.05619999$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.05619999$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

---

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---

$$s_u(4.9) = 0.16690234$$

$$\mu = M_{Rc}(4.14) = 1.7252E+008$$

$$u = s_u(4.1) = 1.7214953E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 600261.003$

Calculation of Shear Strength at edge 1,  $V_{r1} = 600261.003$

$$V_{r1} = V_{Col}((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 600261.003$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 28.23333$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu = 1.0002017E-011$$

$$V_u = 1.3927229E-031$$

$$d = 0.8 * h = 320.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$$s/d = 0.3125$$

$V_{s2} = 0.00$  is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.44$$

$$s = 250.00$$

$V_{s2}$  is multiplied by  $Col2 = 0.00$

$$s/d = 1.5625$$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$$b_w = 750.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 600261.003$

$$V_{r2} = V_{Col}((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 600261.003$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0002017E-011$

$\nu_u = 1.3927229E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$b_w = 750.00$

-----  
End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3  
-----

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

Constant Properties  
-----

Knowledge Factor,  $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

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,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.00  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -3.9443045E-031$   
EDGE -B-  
Shear Force,  $V_b = 3.9443045E-031$   
BOTH EDGES  
Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 1137.257$   
-Middle:  $A_{st,mid} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.25537128$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.5366E+008$   
 $\mu_{1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.5366E+008$   
 $\mu_{2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

-----  
Calculation of  $\mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu = 8.5738376E-006$   
 $\mu_u = 3.5366E+008$

-----  
with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\omega (5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \omega) = 0.0052143$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.0052143$

we (5.4c) = 0.00183676  
ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038  
ase1 = 0.12601038  
bo\_1 = 690.00  
ho\_1 = 340.00  
bi2\_1 = 1.1834E+006  
ase2 = Max(ase1,ase2) = 0.12601038  
bo\_2 = 542.00  
ho\_2 = 192.00  
bi2\_2 = 661256.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339

Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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 = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

$$su_2 = 0.4 \cdot esu_{2\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,

For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 367.9498$$

$$\text{with } Es_2 = (Es_{jacket} \cdot Asl_{,com,jacket} + Es_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

$$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv_{nominal}$  and  $yv, shv, ftv, fyv$ , it is considered

characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 389.0139$$

$$\text{with } Esv = (Es_{jacket} \cdot Asl_{,mid,jacket} + Es_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 200000.00$$

$$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04483877$$

$$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483877$$

$$v = Asl_{,mid} / (b \cdot d) \cdot (fsv / fc) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05508907$$

$$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508907$$

$$v = Asl_{,mid} / (b \cdot d) \cdot (fsv / fc) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.1553529$$

$$Mu = MRc (4.14) = 3.5366E+008$$

$$u = su (4.1) = 8.5738376E-006$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu_1$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$Mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e \text{ (5.4c)} = 0.00183676$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $p_{sh, \min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{ou, \min} = l_b / l_d = 0.30$$

$$su_1 = 0.4 * e_{su1\_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{su1\_nominal} = 0.08,$$

For calculation of  $e_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fs_1 = fs_1 / 1.2$ , from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b / l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 367.9498$$

$$\text{with } E_{s1} = (E_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + E_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9498$$

$$\text{with } Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 389.0139$$

$$\text{with } Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.04483877$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.04483877$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.05508907$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.05508907$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---->

$$su (4.9) = 0.1553529$$

$$Mu = MRc (4.14) = 3.5366E+008$$

$$u = su (4.1) = 8.5738376E-006$$

-----  
Calculation of ratio  $lb/ld$

-----  
Inadequate Lap Length with  $lb/ld = 0.30$   
-----  
-----

-----  
Calculation of  $Mu_{2+}$   
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$Mu = 3.5366E+008$$

-----  
with full section properties:

b = 400.00  
d = 707.00  
d' = 43.00  
v = 0.00118049  
N = 11016.808  
fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.0052143$

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) =  $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.12601038$

ase1 = 0.12601038

bo\_1 = 690.00

ho\_1 = 340.00

bi2\_1 = 1.1834E+006

ase2 =  $\text{Max}(ase1, ase2) = 0.12601038$

bo\_2 = 542.00

ho\_2 = 192.00

bi2\_2 = 661256.00

psh,min\*Fywe =  $\text{Min}(psh,x * Fywe, psh,y * Fywe) = 1.60339$

Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
psh\_x\*Fywe =  $psh1 * Fywe1 + ps2 * Fywe2 = 1.60339$

ps1 (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.0020944$

Ash1 =  $A_{stir\_1} * ns\_1 = 157.0796$

No stirrups, ns\_1 = 2.00

h1 = 400.00

ps2 (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00026808$

Ash2 =  $A_{stir\_2} * ns\_2 = 100.531$

No stirrups, ns\_2 = 2.00

h2 = 200.00

-----  
psh\_y\*Fywe =  $psh1 * Fywe1 + ps2 * Fywe2 = 3.13667$

ps1 (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$

Ash1 =  $A_{stir\_1} * ns\_1 = 157.0796$

No stirrups, ns\_1 = 2.00

h1 = 750.00

ps2 (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00073723$

Ash2 =  $A_{stir\_2} * ns\_2 = 100.531$

No stirrups, ns\_2 = 2.00

h2 = 550.00

-----  
Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min =  $lb/d = 0.30$

su1 =  $0.4 * esu1\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$

with  $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 441.5397$   
 $fy_2 = 367.9498$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 367.9498$   
 with  $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 389.0139$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04483877$   
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483877$   
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05508907$   
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508907$   
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_s, y_2$  - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.1553529$   
 $Mu = MRc (4.14) = 3.5366E+008$   
 $u = su (4.1) = 8.5738376E-006$

-----  
 Calculation of ratio  $l_b/l_d$

-----  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----  
 -----

-----  
 Calculation of  $Mu_2$ -  
 -----  
 -----  
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$\mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$w_e(5.4c) = 0.00183676$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $p_{sh, \min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{ou, \min} = l_b / d = 0.30$$

$$su_1 = 0.4 * e_{su1\_nominal}((5.5), \text{TBDY}) = 0.032$$

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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$

with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 441.5397$

$fy2 = 367.9498$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 0.30$

$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9498$

with  $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 466.8167$

$fyv = 389.0139$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.30$

$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered

characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 389.0139$

with  $Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.04483877$

$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.04483877$

$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.01676222$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.05508907$

$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.05508907$

$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs, y2$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.1553529$

$Mu = MRc (4.14) = 3.5366E+008$

$u = su (4.1) = 8.5738376E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 923245.821$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 923245.821$

$V_{r1} = V_{Col} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 923245.821$

$k_{nl} = 1$  (zero step-static loading)  
-----

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 6.8236829E-012$

$V_u = 3.9443045E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 78636.768$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 1.00$

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$bw = 400.00$   
-----

Calculation of Shear Strength at edge 2,  $V_{r2} = 923245.821$

$V_{r2} = V_{Col} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 923245.821$

$k_{nl} = 1$  (zero step-static loading)  
-----

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 6.8236829E-012$

$V_u = 3.9443045E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

s/d = 0.16666667

Vs2 = 78636.768 is calculated for core, with:

d = 440.00

Av = 100530.965

fy = 444.44

s = 250.00

Vs2 is multiplied by Col2 = 1.00

s/d = 0.56818182

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 847147.582

bw = 400.00

-----  
End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

-----  
Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

External Height, H = 400.00

External Width, W = 750.00

Internal Height, H = 200.00

Internal Width, W = 550.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with lb/ld = 0.30

No FRP Wrapping

-----  
Stepwise Properties

Bending Moment, M = -9.7390E+006

Shear Force, V2 = -2823.172

Shear Force, V3 = -3.1363135E-013

Axial Force, F = -15251.406

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 2676.637

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257

-Compression: Asl,com = 1137.257

-Middle: Asl,mid = 402.1239

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten,jacket = 829.3805

-Compression: Asl,com,jacket = 829.3805

-Middle: Asl,mid,jacket = 402.1239

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten,core = 307.8761

-Compression: Asl,com,core = 307.8761

-Middle: Asl,mid,core = 0.00

Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u,R = \rho \cdot u = 0.0323797$   
 $u = \rho \cdot y + \rho = 0.0323797$

- Calculation of  $y$  -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00264439$  ((4.29),Biskinis Phd)

$M_y = 2.5050E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 3449.669

From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.0893E+014$

factor = 0.30

$A_g = 300000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 28.23333$

$N = 15251.406$

$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 3.6310E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 2.6754055E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 296.8915$

$d = 707.00$

$y = 0.21520049$

$A = 0.00964642$

$B = 0.00520186$

with  $pt = 0.00402142$

$pc = 0.00402142$

$pv = 0.00142194$

$N = 15251.406$

$b = 400.00$

$\rho = 0.06082037$

$y_{comp} = 1.4667378E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.21215815$

$A = 0.0093422$

$B = 0.00502021$

with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.02973531$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$

shear control ratio  $V_{yE}/V_{ColOE} = 0.25537128$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00466422$

jacket:  $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$

$A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 750.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00073723$

$A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 550.00$

$s_2 = 250.00$

The term  $2 \cdot t_f/bw \cdot (f_{fe}/f_s)$  is implemented to account for FRP contribution

where  $f = 2 \cdot t_f/bw$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe}/f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation  $f_s$  of jacket is used.

$NUD = 15251.406$

$A_g = 300000.00$

$f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section\_area = 28.23333$

$f_{yIE} = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Reinf} = 529.9972$

$f_{yIE} = (f_{y,ext\_Trans\_Reinf} \cdot s_1 + f_{y,int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 537.9964$

$\rho_l = Area_{Tot\_Long\_Reinf} / (b \cdot d) = 0.00946477$

$b = 400.00$

$d = 707.00$

$f_{cE} = 28.23333$

-----  
End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

-----

## Calculation No. 13

column C1, Floor 1

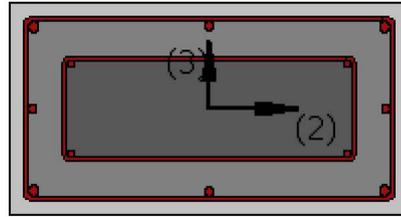
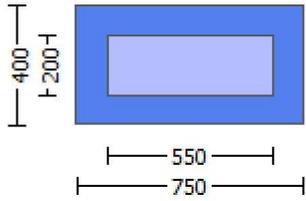
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material: Steel Strength,  $f_s = f_{sm} = 555.56$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material: Steel Strength,  $f_s = f_{sm} = 444.44$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -9.7390E+006$

Shear Force,  $V_a = -2823.172$

EDGE -B-

Bending Moment,  $M_b = 1.2625E+006$

Shear Force,  $V_b = 2823.172$

BOTH EDGES

Axial Force,  $F = -15251.406$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 1137.257$

-Compression:  $A_{sc,com} = 1137.257$

-Middle:  $A_{st,mid} = 402.1239$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = V_n = 824546.066$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 824546.066$

$V_{CoI} = 824546.066$

$k_n = 1.00$

displacement\_ductility\_demand = 0.04881574

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + V_f$ ' where  $V_f$  is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 21.70$ , but  $f'_c^{0.5} \leq 8.3$  MPa ((22.5.3.1), ACI 318-14)

$M/Vd = 2.00$

$M_u = 1.2625E+006$

$V_u = 2823.172$

$d = 0.8 \cdot h = 600.00$

$N_u = 15251.406$

$A_g = 300000.00$

From ((11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 542012.697$

where:

$V_{s1} = 471238.898$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 70773.799$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 1.00$

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From ((11-11), ACI 440:  $V_s + V_f \leq 742690.493$

$bw = 400.00$

displacement\_ductility\_demand is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation =  $1.6733420E-005$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00034279$  ((4.29), Biskinis Phd))

$M_y = 2.5050E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 447.1746

From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.0893E+014$

factor = 0.30  
Ag = 300000.00  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$   
N = 15251.406  
 $E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 3.6310\text{E}+014$

-----  
-----  
Calculation of Yielding Moment My

-----  
Calculation of  $y$  and My according to Annex 7 -

-----  
 $y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 2.6754055\text{E}-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 296.8915$   
d = 707.00  
y = 0.21520049  
A = 0.00964642  
B = 0.00520186  
with pt = 0.00402142  
pc = 0.00402142  
pv = 0.00142194  
N = 15251.406  
b = 400.00  
" = 0.06082037  
 $y_{\text{comp}} = 1.4667378\text{E}-005$   
with  $f_c = 33.00$   
Ec = 26999.444  
y = 0.21215815  
A = 0.0093422  
B = 0.00502021  
with Es = 200000.00

-----  
-----  
Calculation of ratio  $l_b/d$

-----  
Inadequate Lap Length with  $l_b/d = 0.30$

-----  
End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

## Calculation No. 14

column C1, Floor 1

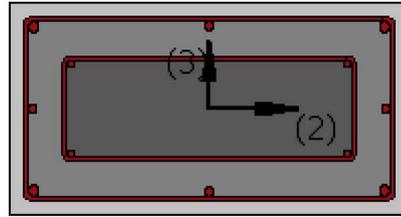
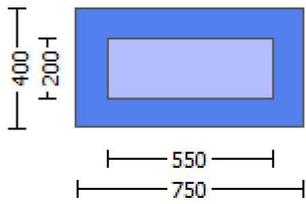
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
 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,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou, \min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -1.3927229E-031$

EDGE -B-

Shear Force,  $V_b = 1.3927229E-031$

BOTH EDGES

Axial Force,  $F = -11016.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{,ten} = 1137.257$

-Compression:  $As_{,com} = 1137.257$

-Middle:  $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.19160863$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 115015.186$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7252E+008$

$Mu_{1+} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7252E+008$

$Mu_{2+} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 1.7214953E-005$

$M_u = 1.7252E+008$

with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.12601038$

$ase_1 = 0.12601038$

$bo_1 = 690.00$

$ho_1 = 340.00$

$bi_{2,1} = 1.1834E+006$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$

$bo_2 = 542.00$

$ho_2 = 192.00$

$bi_{2,2} = 661256.00$

$psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 1.60339$

Expression ((5.4d), TBDY) for  $psh_{,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_{,x} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 1.60339$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir,1} * ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 389.0139$

with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.04735912$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.04735912$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.01770442$

and confined core properties:

$b = 690.00$

$d = 327.00$

$d' = 13.00$

$f_{cc}$  (5A.2, TBDY) = 33.00

$cc$  (5A.5, TBDY) = 0.002

$c$  = confinement factor = 1.00

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05619999$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05619999$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---->

$su$  (4.9) = 0.16690234

$Mu = MRc$  (4.14) = 1.7252E+008

$u = su$  (4.1) = 1.7214953E-005

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----

-----  
Calculation of  $Mu_1$ -  
-----  
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7214953E-005$

$Mu = 1.7252E+008$   
-----

with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.0052143$

we (5.4c) = 0.00183676

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int})/A_{sec} = 0.12601038$

$ase_1 = 0.12601038$

$bo_1 = 690.00$

$ho_1 = 340.00$

$bi_2_1 = 1.1834E+006$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$

$bo_2 = 542.00$

$ho_2 = 192.00$

$bi_2_2 = 661256.00$

$psh_{,min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 1.60339$

Expression ((5.4d), TBDY) for  $psh_{,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 1.60339$   
-----

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.0020944$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00026808$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

---

$$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00073723$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 550.00$$

---

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/ld = 0.30$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu1_{\text{nominal}} = 0.08$ ,

For calculation of  $esu1_{\text{nominal}}$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 367.9498$$

$$\text{with } Es1 = (Es_{\text{jacket}} \cdot Asl, \text{ten, jacket} + Es_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.30$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 367.9498$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$$

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  $\gamma_v$ ,  $sh_v, ft_v, fy_v$ , it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$$\gamma_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04735912$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04735912$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05619999$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05619999$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.16690234$$

$$\mu_u = M_{Rc} (4.14) = 1.7252E+008$$

$$u = s_u (4.1) = 1.7214953E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

$$\mu_u = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e (5.4c) = 0.00183676$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 1.60339$$

Expression ((5.4d), TBDY) for  $psh_{min} * Fy_{we}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * Fy_{we} = psh_1 * Fy_{we1} + ps_2 * Fy_{we2} = 1.60339$$

$$ps_1 \text{ (external)} = (Ash_1 * h_1 / s_1) / A_{sec} = 0.0020944$$

$$Ash_1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirrups, } ns_1 = 2.00$$

$$h_1 = 400.00$$

$$ps_2 \text{ (internal)} = (Ash_2 * h_2 / s_2) / A_{sec} = 0.00026808$$

$$Ash_2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirrups, } ns_2 = 2.00$$

$$h_2 = 200.00$$

$$psh_y * Fy_{we} = psh_1 * Fy_{we1} + ps_2 * Fy_{we2} = 3.13667$$

$$ps_1 \text{ (external)} = (Ash_1 * h_1 / s_1) / A_{sec} = 0.00392699$$

$$Ash_1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirrups, } ns_1 = 2.00$$

$$h_1 = 750.00$$

$$ps_2 \text{ (internal)} = (Ash_2 * h_2 / s_2) / A_{sec} = 0.00073723$$

$$Ash_2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirrups, } ns_2 = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 555.55$$

$$f_{ce} = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{min} = lb/l_{d,min} = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1 / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$$

$$\text{with } Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{min} = lb/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2 / 1.2$ , from table 5.1, TBDY.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9498$$

$$\text{with } Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$f_{yv} = 389.0139$   
 $s_{uv} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 389.0139$   
 with  $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04735912$   
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.04735912$   
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05619999$   
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05619999$   
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $s_u (4.9) = 0.16690234$   
 $\mu_u = M_{Rc} (4.14) = 1.7252E+008$   
 $u = s_u (4.1) = 1.7214953E-005$

-----  
 Calculation of ratio  $l_b/l_d$

-----  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----

-----  
 Calculation of  $\mu_u$ -  
 -----

-----  
 Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7214953E-005$   
 $\mu_u = 1.7252E+008$

-----  
 with full section properties:

$b = 750.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}( \mu_u, cc) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\mu_u = 0.0052143$   
 $w_e (5.4c) = 0.00183676$   
 $\mu_u ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$

$$bi2\_1 = 1.1834E+006$$

$$ase2 = \text{Max}(ase1, ase2) = 0.12601038$$

$$bo\_2 = 542.00$$

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 1.60339$$

Expression ((5.4d), TBDY) for psh, min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.60339$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.0020944$$

$$Ash1 = Astir\_1 * ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00026808$$

$$Ash2 = Astir\_2 * ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 200.00$$

$$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir\_1 * ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00073723$$

$$Ash2 = Astir\_2 * ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/ld = 0.30$$

$$su1 = 0.4 * esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 367.9498$$

$$\text{with } Es1 = (Es, \text{jacket} * Asl, \text{ten, jacket} + Es, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 0.30$$

$$su2 = 0.4 * esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9498$$

$$\text{with } Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$$
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $yv, shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1,ft_1,fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  

$$\text{with } fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$$

$$\text{with } Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04735912$$

$$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04735912$$

$$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01770442$$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05619999$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05619999$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16690234$   
 $Mu = MRc (4.14) = 1.7252E+008$   
 $u = su (4.1) = 1.7214953E-005$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 600261.003$

Calculation of Shear Strength at edge 1,  $V_{r1} = 600261.003$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$   
 $V_{Col0} = 600261.003$   
 $knl = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot fy \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 28.23333$ , but  $fc'^{0.5} < =$   
 8.3 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $Mu = 1.0002017E-011$   
 $Vu = 1.3927229E-031$   
 $d = 0.8 \cdot h = 320.00$   
 $Nu = 11016.808$

Ag = 300000.00  
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
where:  
 $V_{s1} = 279254.914$  is calculated for jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
 $V_{s1}$  is multiplied by Col1 = 1.00  
s/d = 0.3125  
 $V_{s2} = 0.00$  is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
 $V_{s2}$  is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$   
bw = 750.00

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 600261.003$   
 $V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 600261.003  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_{c'}^{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_{c'}^{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00  
Mu = 1.0002017E-011  
Vu = 1.3927229E-031  
d = 0.8\*h = 320.00  
Nu = 11016.808  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
where:  
 $V_{s1} = 279254.914$  is calculated for jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
 $V_{s1}$  is multiplied by Col1 = 1.00  
s/d = 0.3125  
 $V_{s2} = 0.00$  is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
 $V_{s2}$  is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$   
bw = 750.00

-----  
End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

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,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width,  $W = 750.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 550.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou, \min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -3.9443045E-031$

EDGE -B-

Shear Force,  $V_b = 3.9443045E-031$

BOTH EDGES

Axial Force,  $F = -11016.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-Compression:  $A_{slc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl, \text{ten}} = 1137.257$

-Compression:  $A_{sl, \text{com}} = 1137.257$

-Middle:  $A_{sl, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.25537128$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$

with

$$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.5366E+008$$

$Mu_{1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.5366E+008$$

$Mu_{2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 8.5738376E-006$$

$$M_u = 3.5366E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$\omega_e \text{ (5.4c)} = 0.00183676$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $p_{sh, \min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 555.55$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 441.5397$   
 $fy_1 = 367.9498$   
 $su_1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \text{min} = lb/d = 0.30$   
 $su_1 = 0.4 * esu_1 \text{nominal} ((5.5), \text{TBDY}) = 0.032$   
 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  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{\text{jacket}} * A_{sl, \text{ten, jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 367.9498$   
 with  $Es_1 = (Es_{\text{jacket}} * A_{sl, \text{ten, jacket}} + Es_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 441.5397$   
 $fy_2 = 367.9498$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \text{min} = lb/lb, \text{min} = 0.30$   
 $su_2 = 0.4 * esu_2 \text{nominal} ((5.5), \text{TBDY}) = 0.032$   
 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  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{\text{jacket}} * A_{sl, \text{com, jacket}} + fs_{\text{core}} * A_{sl, \text{com, core}}) / A_{sl, \text{com}} = 367.9498$   
 with  $Es_2 = (Es_{\text{jacket}} * A_{sl, \text{com, jacket}} + Es_{\text{core}} * A_{sl, \text{com, core}}) / A_{sl, \text{com}} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \text{min} = lb/d = 0.30$   
 $suv = 0.4 * esuv \text{nominal} ((5.5), \text{TBDY}) = 0.032$   
 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  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{\text{jacket}} * A_{sl, \text{mid, jacket}} + fs_{\text{mid}} * A_{sl, \text{mid, core}}) / A_{sl, \text{mid}} = 389.0139$   
 with  $Es_v = (Es_{\text{jacket}} * A_{sl, \text{mid, jacket}} + Es_{\text{mid}} * A_{sl, \text{mid, core}}) / A_{sl, \text{mid}} = 200000.00$   
 $1 = A_{sl, \text{ten}} / (b * d) * (fs_1 / f_c) = 0.04483877$   
 $2 = A_{sl, \text{com}} / (b * d) * (fs_2 / f_c) = 0.04483877$   
 $v = A_{sl, \text{mid}} / (b * d) * (fsv / f_c) = 0.01676222$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, \text{TBDY}) = 33.00$   
 $cc (5A.5, \text{TBDY}) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl, \text{ten}} / (b * d) * (fs_1 / f_c) = 0.05508907$   
 $2 = A_{sl, \text{com}} / (b * d) * (fs_2 / f_c) = 0.05508907$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture  
satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.1553529$$

$$M_u = M_{Rc}(4.14) = 3.5366E+008$$

$$u = s_u(4.1) = 8.5738376E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $M_{u1}$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$M_u = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e(5.4c) = 0.00183676$$

$$a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$p_{sh, min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $p_{sh, min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} \cdot n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.13667$$

$$p_{s1}(\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir\_2} \cdot n_{s\_2} = 100.531$$

No stirrups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_b,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of 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  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04483877

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04483877

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01676222

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 33.00  
 $c_c$  (5A.5, TBDY) = 0.002  
 $c$  = confinement factor = 1.00  
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05508907$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508907$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su$  (4.9) = 0.1553529  
 $Mu = MR_c$  (4.14) = 3.5366E+008  
 $u = su$  (4.1) = 8.5738376E-006

-----  
 Calculation of ratio  $l_b/l_d$

-----  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----

-----  
 Calculation of  $Mu_{2+}$   
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.5738376E-006$   
 $Mu = 3.5366E+008$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $c_c$  (5A.5, TBDY) = 0.002  
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.0052143$   
 $w_e$  (5.4c) = 0.00183676  
 $ase$  ((5.4d), TBDY) =  $(ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$   
 $psh_{min}*F_{ywe} = \text{Min}(psh_x*F_{ywe}, psh_y*F_{ywe}) = 1.60339$   
 Expression ((5.4d), TBDY) for  $psh_{min}*F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh_x*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 1.60339$   
 $ps1$  (external) =  $(A_{sh1}*h1/s1)/A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir_1}*ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(A_{sh2}*h2/s2)/A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir_2}*ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $psh_y*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 3.13667$   
 $ps1$  (external) =  $(A_{sh1}*h1/s1)/A_{sec} = 0.00392699$

$$\text{Ash1} = \text{Astir}_1 * \text{ns}_1 = 157.0796$$

$$\text{No stirups, ns}_1 = 2.00$$

$$h1 = 750.00$$

$$\text{ps2 (internal)} = (\text{Ash2} * h2 / s2) / \text{Asec} = 0.00073723$$

$$\text{Ash2} = \text{Astir}_2 * \text{ns}_2 = 100.531$$

$$\text{No stirups, ns}_2 = 2.00$$

$$h2 = 550.00$$

$$\text{Asec} = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$\text{fywe1} = 694.45$$

$$\text{fywe2} = 555.55$$

$$\text{fce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: cc} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$\text{sh1} = 0.0044814$$

$$\text{ft1} = 441.5397$$

$$\text{fy1} = 367.9498$$

$$\text{su1} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$\text{lo/lou,min} = \text{lb/ld} = 0.30$$

$$\text{su1} = 0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu1\_nominal} = 0.08,$$

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, \text{sh1,ft1,fy1, are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with fs1} = (\text{fs,jacket} * \text{Asl,ten,jacket} + \text{fs,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 367.9498$$

$$\text{with Es1} = (\text{Es,jacket} * \text{Asl,ten,jacket} + \text{Es,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 200000.00$$

$$y2 = 0.00140044$$

$$\text{sh2} = 0.0044814$$

$$\text{ft2} = 441.5397$$

$$\text{fy2} = 367.9498$$

$$\text{su2} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$\text{lo/lou,min} = \text{lb/lb,min} = 0.30$$

$$\text{su2} = 0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu2\_nominal} = 0.08,$$

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, \text{sh1,ft1,fy1, are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with fs2} = (\text{fs,jacket} * \text{Asl,com,jacket} + \text{fs,core} * \text{Asl,com,core}) / \text{Asl,com} = 367.9498$$

$$\text{with Es2} = (\text{Es,jacket} * \text{Asl,com,jacket} + \text{Es,core} * \text{Asl,com,core}) / \text{Asl,com} = 200000.00$$

$$yv = 0.00140044$$

$$\text{shv} = 0.0044814$$

$$\text{ftv} = 466.8167$$

$$\text{fyv} = 389.0139$$

$$\text{suv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$\text{lo/lou,min} = \text{lb/ld} = 0.30$$

$$\text{suv} = 0.4 * \text{esuv\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esuv\_nominal} = 0.08,$$

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$$y1, \text{sh1,ft1,fy1, are also multiplied by } \text{Min}(1, 1.25 * (\text{lb/ld})^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with fsv} = (\text{fs,jacket} * \text{Asl,mid,jacket} + \text{fs,mid} * \text{Asl,mid,core}) / \text{Asl,mid} = 389.0139$$

$$\text{with Esv} = (\text{Es,jacket} * \text{Asl,mid,jacket} + \text{Es,mid} * \text{Asl,mid,core}) / \text{Asl,mid} = 200000.00$$

$$1 = \text{Asl,ten} / (\text{b} * \text{d}) * (\text{fs1} / \text{fc}) = 0.04483877$$

$$2 = \text{Asl,com} / (\text{b} * \text{d}) * (\text{fs2} / \text{fc}) = 0.04483877$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05508907$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508907$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.1553529$$

$$\mu = M_{Rc} (4.14) = 3.5366E+008$$

$$u = s_u (4.1) = 8.5738376E-006$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_2$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5738376E-006$$

$$\mu = 3.5366E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0052143$$

$$w_e (5.4c) = 0.00183676$$

$$a_{se} ((5.4d), TBDY) = (a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

$$h_{o,1} = 340.00$$

$$b_{i,2,1} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o,2} = 542.00$$

$$h_{o,2} = 192.00$$

$$b_{i,2,2} = 661256.00$$

$$p_{sh,min}*F_{ywe} = \text{Min}(p_{sh,x}*F_{ywe}, p_{sh,y}*F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $p_{sh,min}*F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x}*F_{ywe} = p_{sh1}*F_{ywe1} + p_{sh2}*F_{ywe2} = 1.60339$$

$$p_{s1} (\text{external}) = (A_{sh1}*h_1/s_1)/A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir,1}*n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2}*h_2/s_2)/A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir,2}*n_{s,2} = 100.531$$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 200.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.13667  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00392699  
Ash<sub>1</sub> = Astir<sub>1</sub>\*ns<sub>1</sub> = 157.0796  
No stirups, ns<sub>1</sub> = 2.00  
h<sub>1</sub> = 750.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00073723  
Ash<sub>2</sub> = Astir<sub>2</sub>\*ns<sub>2</sub> = 100.531  
No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 550.00

Asec = 300000.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.45

fywe<sub>2</sub> = 555.55

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y<sub>1</sub> = 0.00140044

sh<sub>1</sub> = 0.0044814

ft<sub>1</sub> = 441.5397

fy<sub>1</sub> = 367.9498

su<sub>1</sub> = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>d</sub> = 0.30

su<sub>1</sub> = 0.4\*esu<sub>1\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>1\_nominal</sub> = 0.08,

For calculation of esu<sub>1\_nominal</sub> and y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, it is considered  
characteristic value fsy<sub>1</sub> = fs<sub>1</sub>/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>1</sub> = (fs<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + fs<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 367.9498

with Es<sub>1</sub> = (Es<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + Es<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 200000.00

y<sub>2</sub> = 0.00140044

sh<sub>2</sub> = 0.0044814

ft<sub>2</sub> = 441.5397

fy<sub>2</sub> = 367.9498

su<sub>2</sub> = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>b,min</sub> = 0.30

su<sub>2</sub> = 0.4\*esu<sub>2\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>2\_nominal</sub> = 0.08,

For calculation of esu<sub>2\_nominal</sub> and y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, it is considered  
characteristic value fsy<sub>2</sub> = fs<sub>2</sub>/1.2, from table 5.1, TBDY.

y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>2</sub> = (fs<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + fs<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 367.9498

with Es<sub>2</sub> = (Es<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + Es<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 200000.00

y<sub>v</sub> = 0.00140044

sh<sub>v</sub> = 0.0044814

ft<sub>v</sub> = 466.8167

fy<sub>v</sub> = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>d</sub> = 0.30

suv = 0.4\*esuv<sub>nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv<sub>nominal</sub> = 0.08,

considering characteristic value fsy<sub>v</sub> = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv<sub>nominal</sub> and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsy<sub>v</sub> = fsv/1.2, from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

1 =  $Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04483877$

2 =  $Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483877$

v =  $Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01676222$

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05508907$

2 =  $Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508907$

v =  $Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v <  $v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.1553529

Mu = MRc (4.14) = 3.5366E+008

u = su (4.1) = 8.5738376E-006

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30  
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 923245.821$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 923245.821$

$V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_{nl} \cdot V_{Col0}$

$V_{Col0} = 923245.821$

$k_{nl} = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 28.23333$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

M/d = 2.00

Mu = 6.8236829E-012

Vu = 3.9443045E-031

d = 0.8 \* h = 600.00

Nu = 11016.808

Ag = 300000.00

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

d = 600.00

$A_v = 157079.633$

$f_y = 555.56$

s = 100.00

$V_{s1}$  is multiplied by  $Col1 = 1.00$

s/d = 0.16666667

$V_{s2} = 78636.768$  is calculated for core, with:

d = 440.00

$A_v = 100530.965$

$f_y = 444.44$

s = 250.00

$V_{s2}$  is multiplied by  $Col2 = 1.00$

s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 847147.582  
bw = 400.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 923245.821  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 923245.821  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*VF'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 28.23333, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 6.8236829E-012

Vu = 3.9443045E-031

d = 0.8\*h = 600.00

Nu = 11016.808

Ag = 300000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 602239.733

where:

Vs1 = 523602.964 is calculated for jacket, with:

d = 600.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.16666667

Vs2 = 78636.768 is calculated for core, with:

d = 440.00

Av = 100530.965

fy = 444.44

s = 250.00

Vs2 is multiplied by Col2 = 1.00

s/d = 0.56818182

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 847147.582

bw = 400.00

-----  
End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

-----  
Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
External Height,  $H = 400.00$   
External Width,  $W = 750.00$   
Internal Height,  $H = 200.00$   
Internal Width,  $W = 550.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = 1.6814758E-011$   
Shear Force,  $V_2 = 2823.172$   
Shear Force,  $V_3 = 3.1363135E-013$   
Axial Force,  $F = -15251.406$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 1137.257$   
-Middle:  $A_{sc,mid} = 402.1239$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,jacket} = 829.3805$   
-Compression:  $A_{sc,com,jacket} = 829.3805$   
-Middle:  $A_{sc,mid,jacket} = 402.1239$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,core} = 307.8761$   
-Compression:  $A_{sc,com,core} = 307.8761$   
-Middle:  $A_{sc,mid,core} = 0.00$   
Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = \gamma + \rho = 0.01790598$

- Calculation of  $\gamma$  -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00198111$  ((4.29), Biskinis Phd))  
 $M_y = 1.2577E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.1741E+013$   
factor = 0.30  
 $A_g = 300000.00$   
Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 28.23333$   
 $N = 15251.406$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 1.0580E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\gamma$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 5.3794571\text{E-}006$   
 with  $((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/l_d)^{2/3}) = 296.8915$   
 $d = 357.00$   
 $y = 0.22703277$   
 $A = 0.01018864$   
 $B = 0.00579229$   
 with  $pt = 0.00424746$   
 $pc = 0.00424746$   
 $pv = 0.00150186$   
 $N = 15251.406$   
 $b = 750.00$   
 $" = 0.12044818$   
 $y_{\text{comp}} = 2.7501333\text{E-}005$   
 with  $fc = 33.00$   
 $Ec = 26999.444$   
 $y = 0.22408338$   
 $A = 0.00986732$   
 $B = 0.00560044$   
 with  $Es = 200000.00$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----

- Calculation of  $p$  -  
 -----

From table 10-8:  $p = 0.01592487$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.19160863$

$d = d_{\text{external}} = 357.00$

$s = s_{\text{external}} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00236248$

jacket:  $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.0020944$

$A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 400.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00026808$

$A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 200.00$

$s_2 = 250.00$

The term  $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 \cdot t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation  $f_s$  of jacket is used.

$NUD = 15251.406$

$A_g = 300000.00$

$f_{cE} = (f_{c\_jacket} \cdot \text{Area}_{\text{jacket}} + f_{c\_core} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 28.23333$

$f_{yI} E = (f_{y\_ext\_Long\_Reinf} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area\_Tot\_Long\_Rein} = 529.9972$

$f_{yT} E = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 542.9506$

$\rho_l = \text{Area\_Tot\_Long\_Rein} / (b \cdot d) = 0.00999678$

$b = 750.00$

$d = 357.00$

$f_{cE} = 28.23333$

-----  
 End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)  
 -----

## Calculation No. 15

column C1, Floor 1

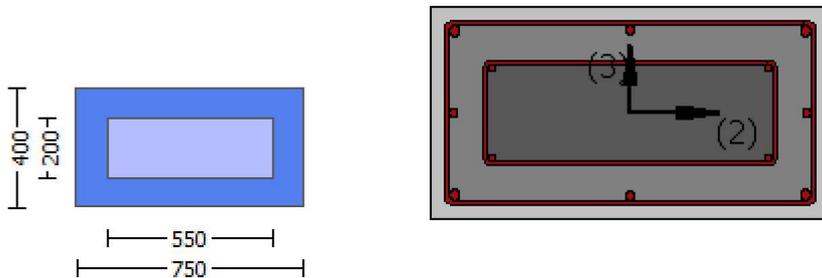
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material: Steel Strength,  $f_s = f_{sm} = 555.56$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material: Steel Strength,  $f_s = f_{sm} = 444.44$   
 #####  
 External Height,  $H = 400.00$   
 External Width,  $W = 750.00$   
 Internal Height,  $H = 200.00$   
 Internal Width,  $W = 550.00$   
 Cover Thickness,  $c = 25.00$   
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 No FRP Wrapping

-----  
 Stepwise Properties  
 -----

EDGE -A-  
 Bending Moment,  $M_a = 9.2596107E-010$   
 Shear Force,  $V_a = -3.1363135E-013$   
 EDGE -B-  
 Bending Moment,  $M_b = 1.6814758E-011$   
 Shear Force,  $V_b = 3.1363135E-013$   
 BOTH EDGES  
 Axial Force,  $F = -15251.406$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{st} = 0.00$   
 -Compression:  $A_{sc} = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st,ten} = 1137.257$   
 -Compression:  $A_{st,com} = 1137.257$   
 -Middle:  $A_{st,mid} = 402.1239$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

-----  
 Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = *V_n = 533860.781$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n * V_{CoI} = 533860.781$   
 $V_{CoI} = 533860.781$   
 $k_n = 1.00$   
 displacement\_ductility\_demand = 0.00

-----  
 NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 = 1 (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 21.70$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 1.6814758E-011$   
 $V_u = 3.1363135E-013$   
 $d = 0.8 * h = 320.00$   
 $N_u = 15251.406$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 251327.412$   
 where:  
 $V_{s1} = 251327.412$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$

Vs2 = 0.00 is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 400.00  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 742690.493  
bw = 750.00

displacement\_ductility\_demand is calculated as  $\delta / y$

- Calculation of  $\delta / y$  for END B -  
for rotation axis 2 and integ. section (b)

From analysis, chord rotation = 4.0359928E-021  
 $y = (M_y * L_s / 3) / E_{eff} = 0.00198111$  ((4.29), Biskinis Phd)  
My = 1.2577E+008  
Ls = M/V (with Ls > 0.1\*L and Ls < 2\*L) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.1741E+013$   
factor = 0.30  
Ag = 300000.00  
Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 28.23333$   
N = 15251.406  
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 1.0580E+014$

Calculation of Yielding Moment My

Calculation of  $\delta / y$  and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.3794571E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 296.8915$   
d = 357.00  
y = 0.22703277  
A = 0.01018864  
B = 0.00579229  
with pt = 0.00424746  
pc = 0.00424746  
pv = 0.00150186  
N = 15251.406  
b = 750.00  
" = 0.12044818  
 $y_{comp} = 2.7501333E-005$   
with fc = 33.00  
Ec = 26999.444  
y = 0.22408338  
A = 0.00986732  
B = 0.00560044  
with Es = 200000.00

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

End Of Calculation of Shear Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (b)

## Calculation No. 16

column C1, Floor 1

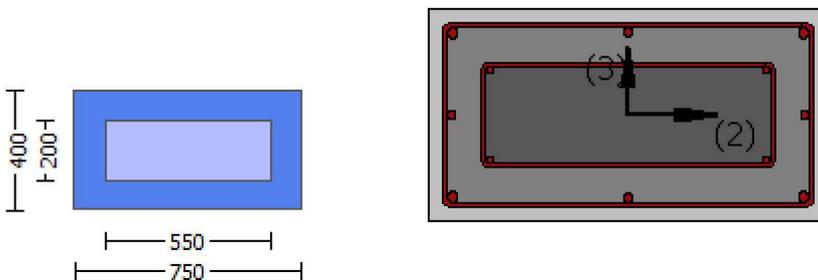
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$

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,  $f_s = 1.25 * f_{sm} = 694.45$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 * f_{sm} = 555.55$

#####

External Height,  $H = 400.00$

External Width, W = 750.00  
Internal Height, H = 200.00  
Internal Width, W = 550.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 3000.00  
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -1.3927229E-031$   
EDGE -B-  
Shear Force,  $V_b = 1.3927229E-031$   
BOTH EDGES  
Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 1137.257$   
-Middle:  $A_{sc,mid} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 0.19160863$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 115015.186$   
with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.7252E+008$   
 $M_{u1+} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $M_{u1-} = 1.7252E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.7252E+008$   
 $M_{u2+} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $M_{u2-} = 1.7252E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 1.7214953E-005$   
 $M_u = 1.7252E+008$

-----  
with full section properties:

b = 750.00  
d = 357.00  
d' = 43.00  
v = 0.00124684  
N = 11016.808  
f<sub>c</sub> = 33.00  
c<sub>o</sub> (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$

$a_{se1} = 0.12601038$

$b_{o\_1} = 690.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 1.1834E+006$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$

$b_{o\_2} = 542.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 661256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$

Expression ((5.4d), TBDY) for  $p_{sh, \min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

-----  
 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 750.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 550.00$

-----  
 $A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 555.55$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.002$

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.5397$

$fy_1 = 367.9498$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 0.30$

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 367.9498$

with  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30

-----  
Calculation of Mu1-

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 1.7214953E-005

Mu = 1.7252E+008

-----  
with full section properties:

b = 750.00

d = 357.00

$d' = 43.00$   
 $v = 0.00124684$   
 $N = 11016.808$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.0052143$   
 $w_e (5.4c) = 0.00183676$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase2 = Max(ase1, ase2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$   
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.60339$   
 Expression ((5.4d), TBDY) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 1.60339$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.0020944$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00026808$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 200.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.13667$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00073723$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 550.00$

$A_{sec} = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 555.55$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c = confinement\ factor = 1.00$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.5397$   
 $fy1 = 367.9498$   
 $su1 = 0.00512$

using (30) in Bisikinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/d = 0.30$

$su1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 367.9498$

with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.00140044$

$$sh_2 = 0.0044814$$

$$ft_2 = 441.5397$$

$$fy_2 = 367.9498$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2$ ,  $sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 367.9498$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $yv$ ,  $shv, ftv, fyv$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$$

$$\text{with } Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.04735912$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04735912$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05619999$$

$$2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05619999$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02100943$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.16690234$$

$$Mu = MRc (4.14) = 1.7252E+008$$

$$u = su (4.1) = 1.7214953E-005$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu_{2+}$

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

Mu = 1.7252E+008

with full section properties:

b = 750.00

d = 357.00

d' = 43.00

v = 0.00124684

N = 11016.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.0052143

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038

ase1 = 0.12601038

bo\_1 = 690.00

ho\_1 = 340.00

bi2\_1 = 1.1834E+006

ase2 = Max(ase1,ase2) = 0.12601038

bo\_2 = 542.00

ho\_2 = 192.00

bi2\_2 = 661256.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339

Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339

ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944

Ash1 = Astir\_1\*ns\_1 = 157.0796

No stirrups, ns\_1 = 2.00

h1 = 400.00

ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808

Ash2 = Astir\_2\*ns\_2 = 100.531

No stirrups, ns\_2 = 2.00

h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667

ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699

Ash1 = Astir\_1\*ns\_1 = 157.0796

No stirrups, ns\_1 = 2.00

h1 = 750.00

ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723

Ash2 = Astir\_2\*ns\_2 = 100.531

No stirrups, ns\_2 = 2.00

h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered

characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 367.9498$

with  $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

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  $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 367.9498$

with  $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_v = 0.4 \cdot esu_{v,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu_{v,nominal} = 0.08$ ,

considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $esu_{v,nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered

characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 389.0139$

with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.04735912$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.04735912$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.01770442$

and confined core properties:

$b = 690.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05619999$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05619999$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.16690234$

$Mu = MRc (4.14) = 1.7252E+008$

$u = su (4.1) = 1.7214953E-005$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$

-----  
Calculation of  $Mu_2$ -

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7214953E-005$$

$$\mu = 1.7252E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0052143$$

$$\phi_w(5.4c) = 0.00183676$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o1} = 690.00$$

$$h_{o1} = 340.00$$

$$b_{i21} = 1.1834E+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o2} = 542.00$$

$$h_{o2} = 192.00$$

$$b_{i22} = 661256.00$$

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.60339$$

Expression ((5.4d), TBDY) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 750.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 555.55$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 441.5397$$

$$fy_1 = 367.9498$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 389.0139

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04735912

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04735912

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01770442

and confined core properties:

b = 690.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05619999

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05619999

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.02100943

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16690234

Mu = MRc (4.14) = 1.7252E+008

u = su (4.1) = 1.7214953E-005

-----  
Calculation of ratio lb/d  
-----

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 600261.003$

Calculation of Shear Strength at edge 1,  $V_{r1} = 600261.003$

$V_{r1} = V_{Co1} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{Co10}$

$V_{Co10} = 600261.003$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0002017E-011$

$V_u = 1.3927229E-031$

$d = 0.8 * h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$b_w = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 600261.003$

$V_{r2} = V_{Co2} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{Co10}$

$V_{Co10} = 600261.003$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0002017E-011$

$V_u = 1.3927229E-031$

$d = 0.8 * h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.3125  
Vs2 = 0.00 is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.44  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 847147.582  
bw = 750.00

-----  
-----  
End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcjrs

Constant Properties

-----  
Knowledge Factor, = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00  
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44  
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 = 694.45  
Existing Column  
Existing material: Steel Strength, fs = 1.25\*fsm = 555.55  
#####  
External Height, H = 400.00  
External Width, W = 750.00  
Internal Height, H = 200.00  
Internal Width, W = 550.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 3000.00  
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with lo/lou,min = 0.30  
No FRP Wrapping

-----  
Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -3.9443045E-031$   
EDGE -B-  
Shear Force,  $V_b = 3.9443045E-031$   
BOTH EDGES  
Axial Force,  $F = -11016.808$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 1137.257$   
-Middle:  $A_{sc,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.25537128$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 235770.47$   
with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.5366E+008$   
 $M_{u1+} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $M_{u1-} = 3.5366E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.5366E+008$   
 $M_{u2+} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $M_{u2-} = 3.5366E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5738376E-006$   
 $M_u = 3.5366E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha_1$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0052143$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.0052143$   
 $\omega_e$  (5.4c) = 0.00183676  
 $\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.12601038$   
 $\alpha_{se1} = 0.12601038$   
 $b_{o1} = 690.00$   
 $h_{o1} = 340.00$   
 $b_{i21} = 1.1834E+006$   
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$   
 $b_{o2} = 542.00$   
 $h_{o2} = 192.00$   
 $b_{i22} = 661256.00$   
 $\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 1.60339$   
Expression ((5.4d), TBDY) for  $\phi_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9498

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lo<sub>u,min</sub> = lb/ld = 0.30

su<sub>v</sub> = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fs<sub>yv</sub> = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered characteristic value fs<sub>yv</sub> = fsv/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/ld)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fsv = (fs<sub>jacket</sub>\*As<sub>l,mid,jacket</sub> + fs<sub>mid</sub>\*As<sub>l,mid,core</sub>)/As<sub>l,mid</sub> = 389.0139

with Es<sub>v</sub> = (Es<sub>jacket</sub>\*As<sub>l,mid,jacket</sub> + Es<sub>mid</sub>\*As<sub>l,mid,core</sub>)/As<sub>l,mid</sub> = 200000.00

1 = As<sub>l,ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.04483877

2 = As<sub>l,com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.04483877

v = As<sub>l,mid</sub>/(b\*d)\*(fsv/fc) = 0.01676222

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = As<sub>l,ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.05508907

2 = As<sub>l,com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.05508907

v = As<sub>l,mid</sub>/(b\*d)\*(fsv/fc) = 0.02059413

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.1553529

Mu = MRc (4.14) = 3.5366E+008

u = su (4.1) = 8.5738376E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.5738376E-006

Mu = 3.5366E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00118049

N = 11016.808

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.0052143

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.0052143

we (5.4c) = 0.00183676

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.12601038

ase1 = 0.12601038

bo\_1 = 690.00

ho\_1 = 340.00

bi2\_1 = 1.1834E+006

ase2 = Max(ase1,ase2) = 0.12601038

bo\_2 = 542.00

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.60339$$

Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.60339$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.0020944$$

$$Ash1 = Astir\_1*ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00026808$$

$$Ash2 = Astir\_2*ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 200.00$$

$$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.13667$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$$

$$Ash1 = Astir\_1*ns\_1 = 157.0796$$

$$\text{No stirrups, } ns\_1 = 2.00$$

$$h1 = 750.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00073723$$

$$Ash2 = Astir\_2*ns\_2 = 100.531$$

$$\text{No stirrups, } ns\_2 = 2.00$$

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 555.55$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 441.5397$$

$$fy1 = 367.9498$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$su1 = 0.4*esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9498$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.5397$$

$$fy2 = 367.9498$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9498$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.00140044$$

$shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 389.0139$   
 with  $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04483877$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.04483877$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.05508907$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.05508907$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < vs,y2$  - LHS eq.(4.5) is satisfied

---

$su (4.9) = 0.1553529$   
 $Mu = MRc (4.14) = 3.5366E+008$   
 $u = su (4.1) = 8.5738376E-006$

-----  
 Calculation of ratio  $lb/ld$

-----  
 Inadequate Lap Length with  $lb/ld = 0.30$   
 -----  
 -----

-----  
 Calculation of  $Mu2+$   
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.5738376E-006$   
 $Mu = 3.5366E+008$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max( cu, cc) = 0.0052143$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.0052143$   
 $we (5.4c) = 0.00183676$   
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.12601038$   
 $ase1 = 0.12601038$

bo\_1 = 690.00  
ho\_1 = 340.00  
bi2\_1 = 1.1834E+006  
ase2 = Max(ase1,ase2) = 0.12601038  
bo\_2 = 542.00  
ho\_2 = 192.00  
bi2\_2 = 661256.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.60339

Expression ((5.4d), TBDY) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 1.60339  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.0020944  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00026808  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.13667  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00073723  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 550.00

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 555.55

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.5397

fy1 = 367.9498

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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 = 367.9498

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.5397

fy2 = 367.9498

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value  $f_{s2} = f_{s2}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s2} = (f_{s,jacket} \cdot A_{s1,com,jacket} + f_{s,core} \cdot A_{s1,com,core})/A_{s1,com} = 367.9498$

with  $E_{s2} = (E_{s,jacket} \cdot A_{s1,com,jacket} + E_{s,core} \cdot A_{s1,com,core})/A_{s1,com} = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$f_{y_v} = 389.0139$

$s_{u_v} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$s_{u_v} = 0.4 \cdot e_{s_{u_v,nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $e_{s_{u_v,nominal}} = 0.08$ ,

considering characteristic value  $f_{s_{y_v}} = f_{s_{y_v}}/1.2$ , 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  $f_{s_{y_v}} = f_{s_{y_v}}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s_{y_v}} = (f_{s,jacket} \cdot A_{s1,mid,jacket} + f_{s,mid} \cdot A_{s1,mid,core})/A_{s1,mid} = 389.0139$

with  $E_{s_{y_v}} = (E_{s,jacket} \cdot A_{s1,mid,jacket} + E_{s,mid} \cdot A_{s1,mid,core})/A_{s1,mid} = 200000.00$

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.04483877$

$2 = A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.04483877$

$v = A_{s1,mid}/(b \cdot d) \cdot (f_{s_{y_v}}/f_c) = 0.01676222$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05508907$

$2 = A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05508907$

$v = A_{s1,mid}/(b \cdot d) \cdot (f_{s_{y_v}}/f_c) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.1553529$

$\mu_u = MR_c (4.14) = 3.5366E+008$

$u = s_u (4.1) = 8.5738376E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{u2}$ -

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.5738376E-006$

$\mu_u = 3.5366E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

$cc (5A.5, TBDY) = 0.002$

Final value of  $\mu_{cu}$ :  $\mu_{cu}^* = \text{shear\_factor} \cdot \text{Max}(c_u, cc) = 0.0052143$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0052143$

$w_e$  (5.4c) = 0.00183676

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$

$a_{se1} = 0.12601038$

$b_{o\_1} = 690.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 1.1834E+006$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$

$b_{o\_2} = 542.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 661256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 1.60339$

Expression ((5.4d), TBDY) for  $p_{sh, \min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.60339$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

-----  
 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.13667$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirrups,  $n_{s\_1} = 2.00$

$h_1 = 750.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirrups,  $n_{s\_2} = 2.00$

$h_2 = 550.00$

-----  
 $A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 555.55$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.002$

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.5397$

$fy_1 = 367.9498$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 0.30$

$su_1 = 0.4 * e_{su1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $e_{su1\_nominal} = 0.08$ ,

For calculation of  $e_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_{s1} / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 367.9498$

with  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 441.5397$

$fy_2 = 367.9498$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with

$$\text{Shear\_factor} = 1.00$$

$$l_0/l_{0u,\min} = l_b/l_{b,\min} = 0.30$$

$$s_u2 = 0.4 \cdot e_{su2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY:  $e_{su2\_nominal} = 0.08$ ,

For calculation of  $e_{su2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{s,jacket} \cdot A_{s1,com,jacket} + f_{s,core} \cdot A_{s1,com,core}) / A_{s1,com} = 367.9498$$

$$\text{with } E_{s2} = (E_{s,jacket} \cdot A_{s1,com,jacket} + E_{s,core} \cdot A_{s1,com,core}) / A_{s1,com} = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$$l_0/l_{0u,\min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 \cdot e_{suv\_nominal} ((5.5), \text{TBDY}) = 0.032$$

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.

$$\text{with } f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 389.0139$$

$$\text{with } E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04483877$$

$$2 = A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483877$$

$$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, \text{TBDY}) = 33.00$$

$$c_c (5A.5, \text{TBDY}) = 0.002$$

$c$  = confinement factor = 1.00

$$1 = A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05508907$$

$$2 = A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508907$$

$$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.1553529$$

$$\mu_u = M_{Rc} (4.14) = 3.5366E+008$$

$$u = s_u (4.1) = 8.5738376E-006$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 923245.821$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 923245.821$

$$V_{r1} = V_{Col} ((10.3), \text{ASCE 41-17}) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 923245.821$$

$k_{nl} = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.8236829E-012$

$\nu_u = 3.9443045E-031$

$d = 0.8 \cdot h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 78636.768$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 1.00$

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 923245.821$

$V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_{nl} \cdot V_{Col0}$

$V_{Col0} = 923245.821$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 28.23333$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.8236829E-012$

$\nu_u = 3.9443045E-031$

$d = 0.8 \cdot h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 602239.733$

where:

$V_{s1} = 523602.964$  is calculated for jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 78636.768$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.44$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 1.00$

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 847147.582$

$bw = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At local axis: 2

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Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (b)  
Section Type: rcjrs

#### Constant Properties

-----  
Knowledge Factor,  $\gamma = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
External Height,  $H = 400.00$   
External Width,  $W = 750.00$   
Internal Height,  $H = 200.00$   
Internal Width,  $W = 550.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

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Bending Moment,  $M = 1.2625E+006$   
Shear Force,  $V_2 = 2823.172$   
Shear Force,  $V_3 = 3.1363135E-013$   
Axial Force,  $F = -15251.406$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 1137.257$   
-Compression:  $A_{sl,com} = 1137.257$   
-Middle:  $A_{sl,mid} = 402.1239$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten,jacket} = 829.3805$   
-Compression:  $A_{sl,com,jacket} = 829.3805$   
-Middle:  $A_{sl,mid,jacket} = 402.1239$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten,core} = 307.8761$   
-Compression:  $A_{sl,com,core} = 307.8761$   
-Middle:  $A_{sl,mid,core} = 0.00$   
Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = u = 0.03007809$   
 $u = y + p = 0.03007809$

-----  
- Calculation of  $y$  -  
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$y = (M_y * L_s / 3) / E_{eff} = 0.00034279$  ((4.29), Biskinis Phd)  
 $M_y = 2.5050E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 447.1746  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.0893E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
Mean concrete strength:  $f'_c = (f'_{c\_jacket} * Area_{jacket} + f'_{c\_core} * Area_{core}) / Area_{section} = 28.23333$   
 $N = 15251.406$   
 $E_c * I_g = E_{c\_jacket} * I_{g\_jacket} + E_{c\_core} * I_{g\_core} = 3.6310E+014$   
-----

-----  
Calculation of Yielding Moment  $M_y$   
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Calculation of  $y$  and  $M_y$  according to Annex 7 -  
-----

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.6754055E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 296.8915$   
 $d = 707.00$   
 $y = 0.21520049$   
 $A = 0.00964642$   
 $B = 0.00520186$   
with  $p_t = 0.00402142$   
 $p_c = 0.00402142$   
 $p_v = 0.00142194$   
 $N = 15251.406$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.4667378E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.21215815$   
 $A = 0.0093422$   
 $B = 0.00502021$   
with  $E_s = 200000.00$   
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-----  
Calculation of ratio  $I_b / I_d$   
-----

Inadequate Lap Length with  $I_b / I_d = 0.30$   
-----

- Calculation of  $p$  -  
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From table 10-8:  $p = 0.02973531$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $I_b / I_d < 1$   
shear control ratio  $V_y E / V_{Col} E = 0.25537128$   
 $d = d_{external} = 707.00$   
 $s = s_{external} = 0.00$   
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00466422$   
jacket:  $s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00392699$   
 $A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction  
 $h_1 = 750.00$   
 $s_1 = 100.00$   
core:  $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00073723$   
 $A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction  
 $h_2 = 550.00$

$$s_2 = 250.00$$

The term  $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$  is implemented to account for FRP contribution where  $f = 2 \cdot t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength. All these variables have already been given in Shear control ratio calculation.

For the normalisation  $f_s$  of jacket is used.

$$N_{UD} = 15251.406$$

$$A_g = 300000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 28.23333$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 529.9972$$

$$f_{yIE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 537.9964$$

$$p_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.00946477$$

$$b = 400.00$$

$$d = 707.00$$

$$f_{cE} = 28.23333$$

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End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

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