

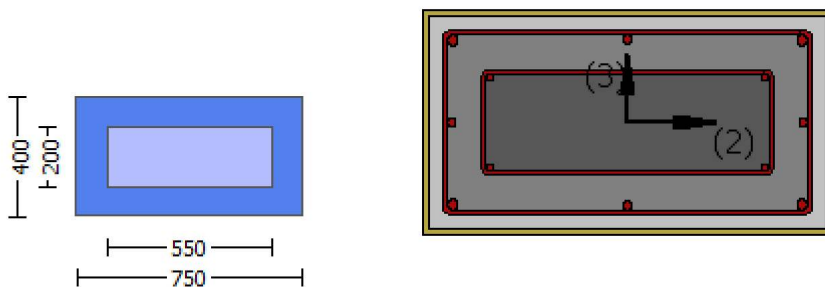
# Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

## Calculation No. 1

column C1, Floor 1  
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity  $V_{Rd}$   
Edge: Start  
Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1  
At local axis: 2  
Integration Section: (a)  
Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 0.90$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of  $\gamma$  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  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
#####  
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,  $L = 3000.00$   
Primary 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  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
FRP Wrapping Data  
Type: Carbon  
Dry properties (design values)  
Thickness,  $t = 1.00$   
Tensile Strength,  $f_{fu} = 840.00$   
Tensile Modulus,  $E_f = 82000.00$   
Elongation,  $efu = 0.009$   
Number of directions,  $NoDir = 1$   
Fiber orientations,  $bi: 0.00^\circ$   
Number of layers,  $NL = 1$   
Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -7.0400E+006$   
Shear Force,  $V_a = -1995.365$   
EDGE -B-  
Bending Moment,  $M_b = 1.0488E+006$   
Shear Force,  $V_b = 1995.365$   
BOTH EDGES  
Axial Force,  $F = -14177.47$   
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:  $As_{mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 948575.705$   
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{CoIO} = 948575.705$

VCol = 948575.705  
knl = 1.00  
displacement\_ductility\_demand = 0.01372547

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:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
M/Vd = 4.00  
Mu = 7.0400E+006  
Vu = 1995.365  
d = 0.8\*h = 600.00  
Nu = 14177.47  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 559706.147  
where:  
Vs1 = 471238.898 is calculated for jacket, with:  
d = 600.00  
Av = 157079.633  
fy = 500.00  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.16666667  
Vs2 = 88467.249 is calculated for core, with:  
d = 440.00  
Av = 100530.965  
fy = 500.00  
s = 250.00  
Vs2 is multiplied by Col2 = 1.00  
s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 463792.00  
f = 0.95, for fully-wrapped sections  
wf/sf = 1 (FRP strips adjacent to one another).  
In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,  
where  $a$  is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,  
as well as for 2 crack directions,  $a = 45^\circ$  and  $a = -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $a_1 = b_1 + 90^\circ = 90.00$   
Vf = Min(|Vf(45, a1)|, |Vf(-45, a1)|), with:  
total thickness per orientation, tf1 = NL\*t/NoDir = 1.00  
dfv = d (figure 11.2, ACI 440) = 707.00  
ffe ((11-5), ACI 440) = 328.00  
Ef = 82000.00  
fe = 0.004, from (11.6a), ACI 440  
with fu = 0.009  
From (11-11), ACI 440: Vs + Vf <= 797164.595  
bw = 400.00

displacement\_ductility\_demand is calculated as  $\delta / y$

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

From analysis, chord rotation  $\theta = 3.7135020E-005$   
 $y = (My \cdot Ls / 3) / Eleff = 0.00270555$  ((4.29), Biskinis Phd))  
My = 2.6204E+008  
Ls = M/V (with  $Ls > 0.1 \cdot L$  and  $Ls < 2 \cdot L$ ) = 3528.173  
From table 10.5, ASCE 41\_17: Eleff = factor\*Ec\*Ig = 1.1390E+014  
factor = 0.30  
Ag = 300000.00  
Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$   
N = 14177.47  
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 3.7968E+014$

Calculation of Yielding Moment  $M_y$

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

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 2.8029545\text{E-}006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25*f_y*(l_b/d)^{2/3}) = 311.2112$   
 $d = 707.00$   
 $y = 0.214783$   
 $A = 0.00962586$   
 $B = 0.0051813$   
with  $p_t = 0.00402142$   
 $p_c = 0.00402142$   
 $p_v = 0.00142194$   
 $N = 14177.47$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{\text{comp}} = 1.4829079\text{E-}005$   
with  $f_c^* (12.3, (ACI 440)) = 33.35516$   
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 400.00$   
 $h = 750.00$   
 $A_g = 300000.00$   
From (12.9), ACI 440:  $k_a = 0.14679369$   
 $g = p_t + p_c + p_v = 0.00946477$   
 $r_c = 40.00$   
 $A_e/A_c = 0.51607158$   
Effective FRP thickness,  $t_f = NL*t*\text{Cos}(b_1) = 1.00$   
effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.21210318$   
 $A = 0.00935205$   
 $B = 0.00502021$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

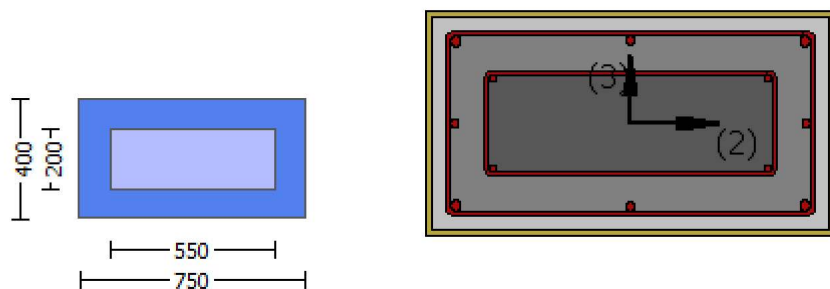
End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

**Calculation No. 2**

column C1, Floor 1  
 Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)  
 Analysis: Uniform +X  
 Check: Chord rotation capacity (  $\phi$  )  
 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,  $\gamma = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

Primary 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  $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $\epsilon_{fu} = 0.009$

Number of directions,  $NoDir = 1$

Fiber orientations,  $bi: 0.00^\circ$

Number of layers,  $NL = 1$

Radius of rounding corners,  $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 3.4586346E-031$

EDGE -B-

Shear Force,  $V_b = -3.4586346E-031$

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,  $V_e/V_r = 0.14265244$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 121055.918$  with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.8158E+008$

$\mu_{u1+} = 1.8158E+008$ , 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

$\mu_{u1-} = 1.8158E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.8158E+008$

$\mu_{u2+} = 1.8158E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 1.8158E+008$ , 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  $\mu_{u1+}$

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

$\phi_u = 1.7255512E-005$

$\mu_u = 1.8158E+008$

with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01006403$

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

From (5.4b), TBDY:  $c_u = 0.01006403$

$w_e$  ((5.4c), TBDY) =  $a_s * \text{sh\_min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$

where  $f = a_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$

$a_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$

$a_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.005$

$bw = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{,f} = 0.015$

$a_s$  ((5.4d), TBDY) =  $(a_{s1} * A_{ext} + a_{s2} * A_{int}) / A_{sec} = 0.12601038$

$a_{s1} = 0.12601038$

$bo\_1 = 690.00$

$ho\_1 = 340.00$

$bi2\_1 = 1.1834E+006$

$a_{s2} = \text{Max}(a_{s1}, a_{s2}) = 0.12601038$

$bo\_2 = 542.00$

$ho\_2 = 192.00$

$bi2\_2 = 661256.00$

$p_{sh,min} * f_{ywe} = \text{Min}(p_{sh,x} * f_{ywe}, p_{sh,y} * f_{ywe}) = 1.64062$

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)

$p_{sh,x} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 1.64062$

$ps1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$

No stirrups,  $ns\_1 = 2.00$

$h_1 = 400.00$

$ps2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$

No stirrups,  $ns\_2 = 2.00$

$h_2 = 200.00$

$p_{sh,y} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 3.23907$

$ps1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$

No stirrups,  $ns\_1 = 2.00$

$h_1 = 750.00$

$ps2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$

No stirrups,  $ns\_2 = 2.00$

$h_2 = 550.00$

$A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$

$c = \text{confinement factor} = 1.0435$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 389.0139$   
 with  $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/lb,min = 0.30$   
 $su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 389.0139$   
 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $Esv = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.0500703$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.0500703$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05941729$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.05941729$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied



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$$su(4.9) = 0.16886055$$

$$Mu = MRc(4.14) = 1.8158E+008$$

$$u = su(4.1) = 1.7255512E-005$$

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:

$$u = 1.7255512E-005$$

$$Mu = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01006403$$

$$we((5.4c), TBDY) = ase * sh_{min} * fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.02692906$$

where  $f = af * pf * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$fx = 0.02504965$$

$$af = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A4.4.3(6), } pf = 2tf/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } ff_e = 800.0873$$

$$fy = 0.04491794$$

$$af = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A4.4.3(6), } pf = 2tf/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } ff_e = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } tf = NL * t * \cos(b1) = 1.00$$

$$fu,f = 840.00$$

$$Ef = 82000.00$$

$$u,f = 0.015$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.12601038$$

$$ase1 = 0.12601038$$

$$bo\_1 = 690.00$$

$$ho\_1 = 340.00$$

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

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

$$bo\_2 = 542.00$$

$$ho\_2 = 192.00$$

$$bi2\_2 = 661256.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 1.64062$$

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)

$psh\_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.0020944$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00026808$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00243499$

$c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 466.8167$

$fy1 = 389.0139$

$su1 = 0.00512$

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

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

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

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

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

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

with  $fs1 = (fs\_jacket \cdot Asl, \text{ten, jacket} + fs\_core \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 389.0139$

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 466.8167$

$fy2 = 389.0139$

$su2 = 0.00512$

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

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

$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

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

with  $fs2 = (fs\_jacket \cdot Asl, \text{com, jacket} + fs\_core \cdot Asl, \text{com, core}) / Asl, \text{com} = 389.0139$

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

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 466.8167$

$fyv = 389.0139$

$suv = 0.00512$

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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.0500703$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.0500703$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05941729$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05941729$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $we ((5.4c), TBDY) = ase * sh_{min} * fy_{we} / fce + Min(fx, fy) = 0.02692906$   
 where  $f = af * pf * ffe / fce$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)  
 -----  
 $fx = 0.02504965$   
 $af = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.00266667$

bw = 750.00  
effective stress from (A.35),  $f_{f,e} = 800.0873$

fy = 0.04491794  
af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
bw = 400.00  
effective stress from (A.35),  $f_{f,e} = 765.1636$

R = 40.00  
Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_f = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$   
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 1.64062$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.23907$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

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  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $su_1 = 0.4 \cdot esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 389.0139$   
with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
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  
 $lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 389.0139$   
with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
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  
 $lo/lou, min = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 389.0139$   
with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.0500703$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.0500703$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.01770442$   
and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.05941729$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05941729$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.02100943$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)  
--->  
 $v < vs, y2$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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:

$$\mu = 1.7255512E-005$$

$$\mu = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01006403$$

$$\mu_e \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.02692906$$

where  $\mu = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.02504965$$

$$a_{se} = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{sh} = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 800.0873$$

$$\mu_y = 0.04491794$$

$$a_{se} = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{sh} = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L^* t \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\mu_{u,f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i,2} = 661256.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 1.64062$$

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

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 550.00$

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00243499

c = confinement factor = 1.0435

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

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 = 389.0139

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

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 = 389.0139

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.0500703$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.0500703$$

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

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.43547$$

$$c_c (5A.5, TBDY) = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05941729$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05941729$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.16886055$$

$$M_u = M_{Rc} (4.14) = 1.8158E+008$$

$$u = s_u (4.1) = 1.7255512E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

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

$$V_{Col0} = 848607.437$$

$k_{nl} = 1$  (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:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$M_u = 3.5345895E-012$$

$$V_u = 3.4586346E-031$$

$$d = 0.8 * h = 320.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

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

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:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

$$V_f ((11-3)-(11.4), ACI 440) = 234192.00$$

$f = 0.95$ , for fully-wrapped sections



$wf/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $Vf(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$Vf = \text{Min}(|Vf(45, \theta)|, |Vf(-45, a1)|)$ , with:

total thickness per orientation,  $tf1 = NL \cdot t / \text{NoDir} = 1.00$

$dfv = d$  (figure 11.2, ACI 440) = 357.00

$ffe$  ((11-5), ACI 440) = 328.00

$Ef = 82000.00$

$fe = 0.004$ , from (11.6a), ACI 440

with  $fu = 0.009$

From (11-11), ACI 440:  $Vs + Vf \leq 915872.391$

$bw = 750.00$

Calculation of Shear Strength at edge 2,  $Vr2 = 848607.437$

$Vr2 = VCol$  ((10.3), ASCE 41-17) =  $knl \cdot VCol0$

$VCol0 = 848607.437$

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

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

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

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

$M/Vd = 2.00$

$\mu_u = 3.5345895E-012$

$\nu_u = 3.4586346E-031$

$d = 0.8 \cdot h = 320.00$

$Nu = 11016.808$

$Ag = 300000.00$

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:

$d = 160.00$

$Av = 100530.965$

$fy = 555.56$

$s = 250.00$

$Vs2$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

$Vf$  ((11-3)-(11.4), ACI 440) = 234192.00

$f = 0.95$ , for fully-wrapped sections

$wf/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $Vf(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$Vf = \text{Min}(|Vf(45, \theta)|, |Vf(-45, a1)|)$ , with:

total thickness per orientation,  $tf1 = NL \cdot t / \text{NoDir} = 1.00$

$dfv = d$  (figure 11.2, ACI 440) = 357.00

$ffe$  ((11-5), ACI 440) = 328.00

$Ef = 82000.00$

$fe = 0.004$ , from (11.6a), ACI 440

with  $fu = 0.009$

From (11-11), ACI 440:  $Vs + Vf \leq 915872.391$

$bw = 750.00$

-----  
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,  $\gamma = 0.90$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
Existing Column  
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
#####  
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 = 1.0435  
Element Length,  $L = 3000.00$   
Primary 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  $l_o/l_{o,min} = 0.30$   
FRP Wrapping Data  
Type: Carbon  
Dry properties (design values)  
Thickness,  $t = 1.00$   
Tensile Strength,  $f_{fu} = 840.00$   
Tensile Modulus,  $E_f = 82000.00$   
Elongation,  $\epsilon_{fu} = 0.009$   
Number of directions,  $N_{oDir} = 1$   
Fiber orientations,  $b_i: 0.00^\circ$   
Number of layers,  $N_L = 1$   
Radius of rounding corners,  $R = 40.00$   
-----

#### Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 2.9582284E-031$

EDGE -B-

Shear Force,  $V_b = -2.9582284E-031$

BOTH EDGES

Axial Force,  $F = -11016.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_{lt} = 0.00$

-Compression:  $As_{lc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{l,com} = 1137.257$

-Middle:  $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.19671905$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$  with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.7261E+008$

$Mu_{1+} = 3.7261E+008$ , 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

$Mu_{1-} = 3.7261E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.7261E+008$

$Mu_{2+} = 3.7261E+008$ , 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

$Mu_{2-} = 3.7261E+008$ , 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:

$\phi_u = 8.5888248E-006$

$M_u = 3.7261E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01006403$

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

From (5.4b), TBDY:  $\phi_u = 0.01006403$

we ((5.4c), TBDY) =  $\phi_u^* = \phi_{co} * \text{shear\_factor} * f_{y,we}/f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.02692906$

where  $\phi_x = \phi_y = \phi_u^* * f_{y,we}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.02504965$

$\phi_y = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A.4.4.3(6),  $\phi_x = 2t_f/b_w = 0.00266667$

$b_w = 750.00$

effective stress from (A.35),  $f_{f,e} = 800.0873$

$f_y = 0.04491794$

$\phi_y = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A.4.4.3(6),  $\phi_y = 2t_f/b_w = 0.005$

$b_w = 400.00$

effective stress from (A.35),  $f_{f,e} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{,f} = 0.015$

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

$a_{se1} = 0.12601038$

$bo\_1 = 690.00$

$ho\_1 = 340.00$

$bi2\_1 = 1.1834E+006$

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

$bo\_2 = 542.00$

$ho\_2 = 192.00$

$bi2\_2 = 661256.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 1.64062$

$ps1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$

No stirrups,  $ns\_1 = 2.00$

$h_1 = 400.00$

$ps2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$

No stirrups,  $ns\_2 = 2.00$

$h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.23907$

$ps1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$

No stirrups,  $ns\_1 = 2.00$

$h_1 = 750.00$

$ps2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$

No stirrups,  $ns\_2 = 2.00$

$h_2 = 550.00$

$A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$

$c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$lo/lo_{u,min} = l_b / l_d = 0.30$

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

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

For calculation of  $esu1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , 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  $\min(1, 1.25 \cdot (l_b / l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_1 = (f_{s,jacket} \cdot A_{s1,ten,jacket} + f_{s,core} \cdot A_{s1,ten,core}) / A_{s1,ten} = 389.0139$

with  $Es_1 = (E_{s,jacket} \cdot A_{s1,ten,jacket} + E_{s,core} \cdot A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

```

fy2 = 389.0139
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,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 = 389.0139
    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,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) = 0.04740567
    2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
    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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
    c = confinement factor = 1.0435
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
    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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008
u = su (4.1) = 8.5888248E-006

```

---

Calculation of ratio lb/ld

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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 = 8.5888248E-006

Mu = 3.7261E+008

---

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha = \text{shear\_factor} * \text{Max}(\alpha_c, \alpha_c) = 0.01006403$$

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

$$\text{From (5.4b), TB DY: } \alpha_c = 0.01006403$$

$$\alpha_{ve} ((5.4c), \text{TB DY}) = \alpha_{se} * \text{sh}_{\min} * f_{yve} / f_{ce} + \text{Min}(\alpha_{fx}, \alpha_{fy}) = 0.02692906$$

where  $\alpha_{fx} = \alpha_{se} * \alpha_{pf} * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\alpha_{fx} = 0.02504965$$

$$\alpha_{se} = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \alpha_{pf} = 2t_f / b_w = 0.00266667$$

$$b_w = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\alpha_{fy} = 0.04491794$$

$$\alpha_{se} = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \alpha_{pf} = 2t_f / b_w = 0.005$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(\beta_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\alpha_{u,f} = 0.015$$

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

$$\alpha_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\alpha_{psh, \min} * F_{yve} = \text{Min}(\alpha_{psh, x} * F_{yve}, \alpha_{psh, y} * F_{yve}) = 1.64062$$

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

$$\alpha_{psh, x} * F_{yve} = \alpha_{psh1} * F_{yve1} + \alpha_{psh2} * F_{yve2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$$\alpha_{psh, y} * F_{yve} = \alpha_{psh1} * F_{yve1} + \alpha_{psh2} * F_{yve2} = 3.23907$$

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

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

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

$$h_1 = 750.00$$

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

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

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

$$h_2 = 550.00$$

```

Asec = 300000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A.5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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 Min(1,1.25*(lb/lb,min)^ 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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499

```

$c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05824278$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05824278$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

$\mu_u(4.9) = 0.15682678$   
 $\mu_u = M_{Rc}(4.14) = 3.7261E+008$   
 $u = \mu_u(4.1) = 8.5888248E-006$

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:

$u = 8.5888248E-006$   
 $\mu_u = 3.7261E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha_{co}(5A.5, TBDY) = 0.002$

Final value of  $\mu_{cu}$ :  $\mu_{cu} = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01006403$

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

From (5.4b), TBDY:  $\mu_{cu} = 0.01006403$

$\mu_{we}((5.4c), TBDY) = \alpha_{se} * \text{sh,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$

where  $f = \alpha_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$

$\alpha_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$

$\alpha_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$

$bw = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = N L * t * \text{Cos}(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{f,f} = 0.015$

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

$\alpha_{se1} = 0.12601038$

$b_{o,1} = 690.00$

$h_{o,1} = 340.00$



$bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 1.64062$   
 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)

$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.0020944$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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

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

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

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

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

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

with  $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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

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

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

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

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

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

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008
u = su (4.1) = 8.5888248E-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 = 8.5888248E-006

Mu = 3.7261E+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) = 0.01006403

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

From (5.4b), TBDY: cu = 0.01006403

we ((5.4c), TBDY) =  $ase \cdot sh_{min} \cdot fy_{we}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
where  $f = af \cdot pf \cdot f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $af = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.00266667$   
 $bw = 750.00$   
effective stress from (A.35),  $ff_e = 800.0873$

$fy = 0.04491794$   
 $af = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.005$   
 $bw = 400.00$   
effective stress from (A.35),  $ff_e = 765.1636$

$R = 40.00$   
Effective FRP thickness,  $tf = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $fu_f = 840.00$   
 $E_f = 82000.00$   
 $u_f = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int})/A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi_{2,1} = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi_{2,2} = 661256.00$

$psh_{min} \cdot fy_{we} = \text{Min}(psh_x \cdot fy_{we}, psh_y \cdot fy_{we}) = 1.64062$   
Expression ((5.4d), TBDY) for  $psh_{min} \cdot fy_{we}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x \cdot fy_{we} = psh_1 \cdot fy_{we1} + ps_2 \cdot fy_{we2} = 1.64062$   
 $ps_1 \text{ (external)} = (Ash_1 \cdot h_1/s_1)/A_{sec} = 0.0020944$   
 $Ash_1 = Astir_1 \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (Ash_2 \cdot h_2/s_2)/A_{sec} = 0.00026808$   
 $Ash_2 = Astir_2 \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$psh_y \cdot fy_{we} = psh_1 \cdot fy_{we1} + ps_2 \cdot fy_{we2} = 3.23907$   
 $ps_1 \text{ (external)} = (Ash_1 \cdot h_1/s_1)/A_{sec} = 0.00392699$   
 $Ash_1 = Astir_1 \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (Ash_2 \cdot h_2/s_2)/A_{sec} = 0.00073723$   
 $Ash_2 = Astir_2 \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$

```

ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
    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 fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with 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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
    c = confinement factor = 1.0435
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
    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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008

```

$$u = su(4.1) = 8.5888248E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.2627E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627E+006$

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

$V_{Col0} = 1.2627E+006$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.3795529E-012$

$\mu_v = 2.9582284E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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  $\text{Col1} = 1.00$

$s/d = 0.16666667$

$V_{s2} = 98297.73$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.56818182$

$V_f((11-3)-(11.4), \text{ACI } 440) = 463792.00$

$f = 0.95$ , for fully-wrapped sections

$w_f/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $t_{f1} = NL * t / \text{NoDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 707.00

$f_{fe}((11-5), \text{ACI } 440) = 328.00$

$E_f = 82000.00$

$f_{fe} = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.2627E+006$

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

$V_{Col0} = 1.2627E+006$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot Area\_jacket + f'_{c\_core} \cdot Area\_core) / Area\_section = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 2.3795529E-012$

$V_u = 2.9582284E-031$

$d = 0.8 \cdot h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 98297.73$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 463792.00

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 707.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$b_w = 400.00$

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,  $\phi = 0.90$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 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,  $L = 3000.00$   
 Primary 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  $l_b/l_d = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $e_{fu} = 0.009$   
 Number of directions,  $N_{oDir} = 1$   
 Fiber orientations,  $b_i: 0.00^\circ$   
 Number of layers,  $N_L = 1$   
 Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

Bending Moment,  $M = 4.7677845E-010$   
 Shear Force,  $V_2 = -1995.365$   
 Shear Force,  $V_3 = -1.4564234E-013$   
 Axial Force,  $F = -14177.47$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{l,com} = 1137.257$   
   -Middle:  $As_{l,mid} = 402.1239$   
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,jacket} = 829.3805$   
   -Compression:  $As_{l,com,jacket} = 829.3805$   
   -Middle:  $As_{l,mid,jacket} = 402.1239$   
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,core} = 307.8761$   
   -Compression:  $As_{l,com,core} = 307.8761$   
   -Middle:  $As_{l,mid,core} = 0.00$   
 Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.00203008$   
 $u = y + p = 0.00203008$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00203008 ((4.29), \text{Biskinis Phd})$

$M_y = 1.3155E+008$   
 $L_s = M/V$  (with  $L_s > 0.1*L$  and  $L_s < 2*L$ ) = 1500.00  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.2399E+013$   
 $factor = 0.30$   
 $A_g = 300000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 14177.47$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 1.0800E+014$

#### Calculation of Yielding Moment $M_y$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.6359183E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$   
 $d = 357.00$   
 $y = 0.22662123$   
 $A = 0.01016692$   
 $B = 0.00577058$   
 with  $p_t = 0.00424746$   
 $p_c = 0.00424746$   
 $p_v = 0.00150186$   
 $N = 14177.47$   
 $b = 750.00$   
 $" = 0.12044818$   
 $y_{comp} = 2.7804373E-005$   
 with  $f_c^*$  (12.3, (ACI 440)) = 33.35499  
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 750.00$   
 $h = 400.00$   
 $A_g = 300000.00$   
 From (12.9), ACI 440:  $k_a = 0.14671972$   
 $g = p_t + p_c + p_v = 0.00999678$   
 $r_c = 40.00$   
 $A_e / A_c = 0.51581153$   
 Effective FRP thickness,  $t_f = N L * t * \cos(b_1) = 1.00$   
 effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.22402532$   
 $A = 0.00987772$   
 $B = 0.00560044$   
 with  $E_s = 200000.00$

#### Calculation of ratio $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $I_b / I_d < 1$   
 shear control ratio  $V_y E / V_{col} O E = 0.14265244$   
 $d = d_{external} = 357.00$   
 $s = s_{external} = 0.00$   
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00393687$   
 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



$$h1 = 400.00$$

$$s1 = 100.00$$

$$\text{core: } s2 = A_{v2} \cdot h2 / (s2 \cdot A_g) = 0.00026808$$

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

$$h2 = 200.00$$

$$s2 = 250.00$$

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.

$$NUD = 14177.47$$

$$A_g = 300000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot \text{Area\_jacket} + f_{c\_core} \cdot \text{Area\_core}) / \text{section\_area} = 33.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot \text{Area\_ext\_Long\_Reinf} + f_{y\_int\_Long\_Reinf} \cdot \text{Area\_int\_Long\_Reinf}) / \text{Area\_Tot\_Long\_Rein} = 555.56$$

$$f_{yIE} = (f_{y\_ext\_Trans\_Reinf} \cdot s1 + f_{y\_int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 555.56$$

$$\rho_l = \text{Area\_Tot\_Long\_Rein} / (b \cdot d) = 0.00999678$$

$$b = 750.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

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

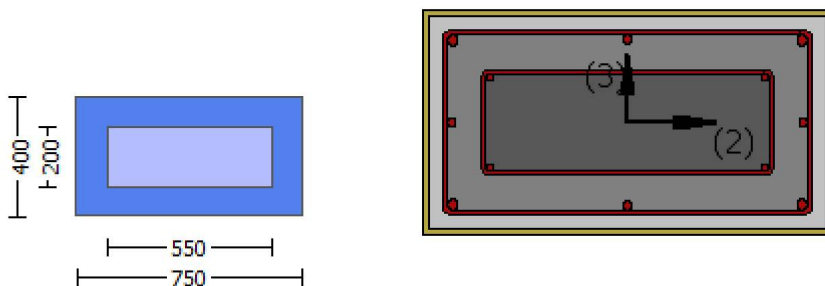
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (3)



```

Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjrs

Constant Properties
-----
Knowledge Factor,  $\gamma = 0.90$ 
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of  $\gamma$  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
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material: Steel Strength,  $f_s = f_{sm} = 555.56$ 
#####
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,  $L = 3000.00$ 
Primary 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  $l_o/l_{ou,min} = l_b/l_d = 0.30$ 
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness,  $t = 1.00$ 
Tensile Strength,  $f_{fu} = 840.00$ 
Tensile Modulus,  $E_f = 82000.00$ 
Elongation,  $\epsilon_{fu} = 0.009$ 
Number of directions,  $N_{oDir} = 1$ 
Fiber orientations,  $b_i: 0.00^\circ$ 
Number of layers,  $N_L = 1$ 
Radius of rounding corners,  $R = 40.00$ 
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment,  $M_a = 4.7677845E-010$ 
Shear Force,  $V_a = -1.4564234E-013$ 
EDGE -B-
Bending Moment,  $M_b = -3.8976464E-011$ 
Shear Force,  $V_b = 1.4564234E-013$ 
BOTH EDGES
Axial Force,  $F = -14177.47$ 

```

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,  $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 776632.031$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 776632.031$

$V_{CoI} = 776632.031$

$k_n = 1.00$

displacement\_ductility\_demand = 0.00

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / V_d = 2.00$

$\mu_u = 4.7677845E-010$

$\nu_u = 1.4564234E-013$

$d = 0.8 \cdot h = 320.00$

$N_u = 14177.47$

$A_g = 300000.00$

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:

$d = 160.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

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

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 234192.00

$f = 0.95$ , for fully-wrapped sections

$w_f / s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 357.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_{e} = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 797164.595$

$b_w = 750.00$

displacement\_ductility\_demand is calculated as  $\delta / y$

- Calculation of  $\phi_y$  for END A -  
for rotation axis 2 and integ. section (a)

From analysis, chord rotation  $\theta = 6.4462528E-021$

$y = (M_y * L_s / 3) / E_{eff} = 0.00203008$  ((4.29), Biskinis Phd))

$M_y = 1.3155E+008$

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

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.2399E+013$

factor = 0.30

$A_g = 300000.00$

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

$N = 14177.47$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 1.0800E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

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

$y_{ten} = 5.6359183E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$

$d = 357.00$

$y = 0.22662123$

$A = 0.01016692$

$B = 0.00577058$

with  $p_t = 0.00424746$

$p_c = 0.00424746$

$p_v = 0.00150186$

$N = 14177.47$

$b = 750.00$

$\alpha = 0.12044818$

$y_{comp} = 2.7804373E-005$

with  $f_c^* (12.3, (ACI 440)) = 33.35499$

$f_c = 33.00$

$I_l = 0.77176471$

$b = 750.00$

$h = 400.00$

$A_g = 300000.00$

From (12.9), ACI 440:  $k_a = 0.14671972$

$g = p_t + p_c + p_v = 0.00999678$

$r_c = 40.00$

$A_e / A_c = 0.51581153$

Effective FRP thickness,  $t_f = N L * t * \cos(\theta_1) = 1.00$

effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$

$f_u = 0.009$

$E_f = 82000.00$

$E_c = 26999.444$

$y = 0.22402532$

$A = 0.00987772$

$B = 0.00560044$

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. 4

column C1, Floor 1

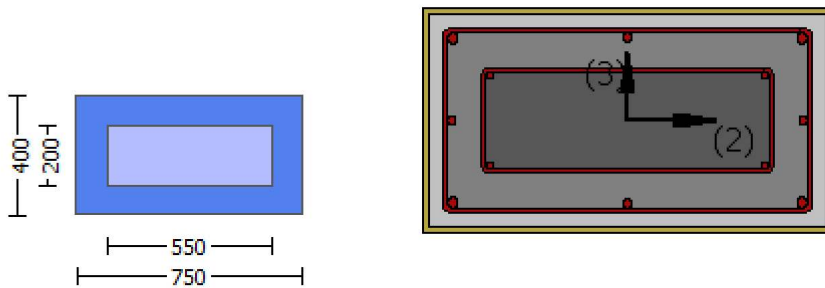
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

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,  $\phi = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435  
 Element Length,  $L = 3000.00$   
 Primary 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  $l_o/l_{ou,min} = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $ε_{fu} = 0.009$   
 Number of directions,  $N_{oDir} = 1$   
 Fiber orientations,  $b_i: 0.00^\circ$   
 Number of layers,  $N_L = 1$   
 Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = 3.4586346E-031$   
 EDGE -B-  
 Shear Force,  $V_b = -3.4586346E-031$   
 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 ,  $V_e/V_r = 0.14265244$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 121055.918$   
 with  
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.8158E+008$   
 $\mu_{u1+} = 1.8158E+008$ , 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  
 $\mu_{u1-} = 1.8158E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.8158E+008$   
 $\mu_{u2+} = 1.8158E+008$ , 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  
 $\mu_{u2-} = 1.8158E+008$ , 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:  
 $\phi_u = 1.7255512E-005$   
 $\mu_u = 1.8158E+008$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01006403$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.01006403$$

$$\alpha_e ((5.4c), \text{TB DY}) = \alpha * \frac{\min(f_{ywe}/f_{ce}, \text{Min}(f_x, f_y))}{f_c} = 0.02692906$$

where  $f = \alpha * \rho_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$\alpha_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$\alpha_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_f = 0.015$$

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

$$\alpha_{se1} = 0.12601038$$

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

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

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

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

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

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

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

$$\rho_{sh, \min} * f_{ywe} = \text{Min}(\rho_{sh, x} * f_{ywe}, \rho_{sh, y} * f_{ywe}) = 1.64062$$

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

$$\rho_{sh, x} * f_{ywe} = \rho_{sh1} * f_{ywe1} + \rho_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$$\rho_{sh, y} * f_{ywe} = \rho_{sh1} * f_{ywe1} + \rho_{sh2} * f_{ywe2} = 3.23907$$

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

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

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

$$h_1 = 750.00$$

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

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

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

$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.5), \text{TB DY}), \text{TB DY: } cc = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

From table 5A.1, TB DY:  $esu_1 \text{ nominal} = 0.08$ ,

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, TB DY.

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

$$\text{with } fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

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

$$su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

From table 5A.1, TB DY:  $esu_2 \text{ nominal} = 0.08$ ,

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, TB DY.

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

$$\text{with } fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$su_v = 0.00512$$

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

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

$$su_v = 0.4 * esuv \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

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

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

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, TB DY.

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.0500703$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.0500703$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TB DY}) = 34.43547$$



$cc(5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05941729$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05941729$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

$su(4.9) = 0.16886055$   
 $Mu = MRc(4.14) = 1.8158E+008$   
 $u = su(4.1) = 1.7255512E-005$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu1$ -

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

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $w_e((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{f,e} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{f,e} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int})/A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $bo_1 = 690.00$

$ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 1.64062$   
 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)

$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.0020944$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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.

with  $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 389.0139$   
 with  $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 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.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.0500703$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.0500703$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.05941729$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.05941729$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.01006403$   
 $w_e ((5.4c), TBDY) = a_{se} \cdot s_{h,min} \cdot f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = a_f \cdot p_f \cdot f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h_1 = 400.00$   
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h_1 = 750.00$   
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$

```

sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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,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 = 389.0139
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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,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 = 389.0139
    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,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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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) = 0.16886055

```

$$\begin{aligned} \mu_u &= M_{Rc} (4.14) = 1.8158E+008 \\ u &= s_u (4.1) = 1.7255512E-005 \end{aligned}$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_u$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 1.7255512E-005$   
 $\mu_u = 1.8158E+008$

with full section properties:

$$\begin{aligned} b &= 750.00 \\ d &= 357.00 \\ d' &= 43.00 \\ v &= 0.00124684 \\ N &= 11016.808 \\ f_c &= 33.00 \\ c_o (5A.5, TBDY) &= 0.002 \end{aligned}$$

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, c_o) = 0.01006403$

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

From (5.4b), TBDY:  $\mu_u = 0.01006403$

we ((5.4c), TBDY) =  $a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\begin{aligned} f_x &= 0.02504965 \\ a_f &= 0.38744444 \\ b &= 750.00 \\ h &= 400.00 \\ \text{From EC8 A.4.4.3(6), } p_f &= 2t_f/bw = 0.00266667 \\ bw &= 750.00 \\ \text{effective stress from (A.35), } f_{fe} &= 800.0873 \end{aligned}$$

$$\begin{aligned} f_y &= 0.04491794 \\ a_f &= 0.38744444 \\ b &= 400.00 \\ h &= 750.00 \\ \text{From EC8 A.4.4.3(6), } p_f &= 2t_f/bw = 0.005 \\ bw &= 400.00 \\ \text{effective stress from (A.35), } f_{fe} &= 765.1636 \end{aligned}$$

$$\begin{aligned} R &= 40.00 \\ \text{Effective FRP thickness, } t_f &= NL * t * \cos(b_1) = 1.00 \\ f_{u,f} &= 840.00 \\ E_f &= 82000.00 \\ u_{f,f} &= 0.015 \\ a_{se} ((5.4d), TBDY) &= (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038 \\ a_{se1} &= 0.12601038 \\ b_{o\_1} &= 690.00 \\ h_{o\_1} &= 340.00 \\ b_{i2\_1} &= 1.1834E+006 \\ a_{se2} &= \text{Max}(a_{se1}, a_{se2}) = 0.12601038 \\ b_{o\_2} &= 542.00 \\ h_{o\_2} &= 192.00 \\ b_{i2\_2} &= 661256.00 \end{aligned}$$

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.64062$$

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)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.64062$$

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

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

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

$$h1 = 400.00$$

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

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

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

$$h2 = 200.00$$

$$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.23907$$

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

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

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

$$h1 = 750.00$$

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

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

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

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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.

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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.

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

$l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 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  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $f_{yv}$ , it is considered  
 characteristic value  $f_{syv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{sj\_jacket} * A_{sl,mid,jacket} + f_{sj\_mid} * A_{sl,mid,core}) / A_{sl,mid} = 389.0139$   
 with  $E_{sv} = (E_{sj\_jacket} * A_{sl,mid,jacket} + E_{sj\_mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.0500703$   
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.0500703$   
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.05941729$   
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.05941729$   
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.02100943$

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

----

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

----

$su (4.9) = 0.16886055$   
 $Mu = MR_c (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{ColO}$   
 $V_{ColO} = 848607.437$   
 $k_{nl} = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $Mu = 3.5345895E-012$   
 $Vu = 3.4586346E-031$   
 $d = 0.8 * h = 320.00$   
 $Nu = 11016.808$   
 $Ag = 300000.00$   
 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  $Col1 = 1.00$   
 $s/d = 0.3125$



Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 234192.00$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,

where  $\alpha$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ , as well as for 2 crack directions,  $\alpha = 45^\circ$  and  $\alpha = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\alpha = b1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, \alpha)|, |V_f(-45, \alpha)|), \text{ with:}$$

$$\text{total thickness per orientation, } t_{f1} = N_L * t / N_{\text{Dir}} = 1.00$$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 357.00$$

$$f_{fe}((11-5), \text{ACI 440}) = 328.00$$

$$E_f = 82000.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.009$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 915872.391$$

$$b_w = 750.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 848607.437$

$$V_{r2} = V_{\text{Col}}((10.3), \text{ASCE 41-17}) = k_n l * V_{\text{ColO}}$$

$$V_{\text{ColO}} = 848607.437$$

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

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\mu_u = 3.5345895E-012$$

$$V_u = 3.4586346E-031$$

$$d = 0.8 * h = 320.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

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

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:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 234192.00$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,

where  $\alpha$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ , as well as for 2 crack directions,  $\alpha = 45^\circ$  and  $\alpha = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\alpha = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$   
 $df_v = d$  (figure 11.2, ACI 440) = 357.00  
 $ff_e ((11-5), \text{ACI 440}) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 750.00$

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,  $\phi = 0.90$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:

Jacket

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

Existing Column

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

#####

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

Jacket

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

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $ff_u = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $ef_u = 0.009$

Number of directions,  $\text{NoDir} = 1$

Fiber orientations,  $bi: 0.00^\circ$

Number of layers, NL = 1  
Radius of rounding corners, R = 40.00

#### Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force, Va = 2.9582284E-031  
EDGE -B-  
Shear Force, Vb = -2.9582284E-031  
BOTH EDGES  
Axial Force, F = -11016.808  
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

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19671905$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.7261\text{E}+008$   
 $\mu_{1+} = 3.7261\text{E}+008$ , 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  
 $\mu_{1-} = 3.7261\text{E}+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.7261\text{E}+008$   
 $\mu_{2+} = 3.7261\text{E}+008$ , 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  
 $\mu_{2-} = 3.7261\text{E}+008$ , 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  $\mu$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu = 8.5888248\text{E}-006$   
 $\mu_u = 3.7261\text{E}+008$

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  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.01006403$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.01006403$   
 $\mu_{ve}$  ((5.4c), TBDY) =  $a_s e^* \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)  
 $f_x = 0.02504965$   
 $a_f = 0.38744444$   
b = 750.00  
h = 400.00  
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$

bw = 750.00  
effective stress from (A.35),  $f_{f,e} = 800.0873$

fy = 0.04491794  
af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
bw = 400.00  
effective stress from (A.35),  $f_{f,e} = 765.1636$

R = 40.00  
Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_f = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$   
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.64062$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.23907$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

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  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $su_1 = 0.4 \cdot esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 389.0139$   
with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
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  
 $lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 389.0139$   
with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
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.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 389.0139$   
with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.04740567$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.04740567$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.01676222$   
and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.05824278$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05824278$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.02059413$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)  
--->  
 $v < vs, y2$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

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:

$$\mu = 8.5888248E-006$$

$$Mu = 3.7261E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01006403$$

$$\mu_e \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.02692906$$

where  $\mu = a_f * \mu_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f / b_w = 0.00266667$$

$$b_w = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\mu_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f / b_w = 0.005$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\mu_{f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 1.64062$$

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

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 550.00$

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00243499

c = confinement factor = 1.0435

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

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 = 389.0139

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

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 = 389.0139

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04740567$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.04740567$$

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

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.43547$$

$$cc (5A.5, TBDY) = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05824278$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05824278$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.15682678$$

$$\mu_u = M_{Rc} (4.14) = 3.7261E+008$$

$$u = su (4.1) = 8.5888248E-006$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2+}$

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

$$u = 8.5888248E-006$$

$$\mu_u = 3.7261E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01006403$$

$$w_e ((5.4c), TBDY) = a_{se} * sh_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$



$R = 40.00$   
 Effective FRP thickness,  $t_f = N_L * t * \cos(b_1) = 1.00$   
 $f_u, f = 840.00$   
 $E_f = 82000.00$   
 $u, f = 0.015$   
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi_2_1 = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi_2_2 = 661256.00$   
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.64062$   
 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)

$psh, x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 1.64062$   
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir\_2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$psh, y * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 3.23907$   
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir\_2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

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

$lo/lo_{u, \min} = l_b / l_d = 0.30$

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

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

with  $fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 389.0139$

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

$y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 389.0139$   
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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$   
with  $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.04740567$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04740567$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01676222$   
and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05824278$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05824278$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02059413$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

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

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

Calculation of  $Mu_2$ -  
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-----

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

$u = 8.5888248E-006$   
 $Mu = 3.7261E+008$   
-----

with full section properties:

$b = 400.00$

$d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
 Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\alpha = 0.01006403$   
 $\alpha_{we} ((5.4c), TBDY) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = \alpha * \rho_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $\alpha_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $\rho_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $\alpha_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $\rho_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.12601038$   
 $\alpha_{se1} = 0.12601038$   
 $b_{o,1} = 690.00$   
 $h_{o,1} = 340.00$   
 $b_{i2,1} = 1.1834E+006$   
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$   
 $b_{o,2} = 542.00$   
 $h_{o,2} = 192.00$   
 $b_{i2,2} = 661256.00$

$\rho_{sh, \min} * F_{ywe} = \text{Min}(\rho_{sh, x} * F_{ywe}, \rho_{sh, y} * F_{ywe}) = 1.64062$   
 Expression ((5.4d), TBDY) for  $\rho_{sh, \min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\rho_{sh, x} * F_{ywe} = \rho_{sh1} * F_{ywe1} + \rho_{sh2} * F_{ywe2} = 1.64062$   
 $\rho_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 400.00$   
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 200.00$

$\rho_{sh, y} * F_{ywe} = \rho_{sh1} * F_{ywe1} + \rho_{sh2} * F_{ywe2} = 3.23907$   
 $\rho_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 750.00$   
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$

```

s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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 fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with 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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278

```

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05824278$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u(4.9) = 0.15682678$$

$$M_u = M_{Rc}(4.14) = 3.7261E+008$$

$$u = s_u(4.1) = 8.5888248E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 1.2627E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627E+006$

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

$$V_{Col0} = 1.2627E+006$$

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

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

$= 1$  (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$M_u = 2.3795529E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 * h = 600.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 621900.694$$

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  $Col1 = 1.00$

$$s/d = 0.16666667$$

$V_{s2} = 98297.73$  is calculated for core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 0.56818182$$

$$V_f((11-3)-(11.4), ACI 440) = 463792.00$$

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,

where  $\alpha$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ , as well as for 2 crack directions,  $\alpha = 45^\circ$  and  $\alpha = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\alpha = b1 + 90^\circ = 90.00$

$$V_f = \min(|V_f(45, \alpha)|, |V_f(-45, \alpha)|), \text{ with:}$$

total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.00$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 707.00$$

$$f_{fe}((11-5), ACI 440) = 328.00$$

$$E_f = 82000.00$$

$f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.2627E+006$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$   
 $V_{Col0} = 1.2627E+006$   
 $knl = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M / Vd = 2.00$   
 $\mu_u = 2.3795529E-012$   
 $V_u = 2.9582284E-031$   
 $d = 0.8 * h = 600.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$   
 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  $Col1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s2} = 98297.73$  is calculated for core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 463792.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $w_f / s_f = 1$  (FRP strips adjacent to one another).  
 In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,  
 where  $a$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(, )$ , is implemented for every different fiber orientation  $a_i$ ,  
 as well as for 2 crack directions,  $a = 45^\circ$  and  $a = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $a_1 = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = NL * t / NoDir = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 707.00  
 $f_{fe} ((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
 At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
 At local axis: 3  
 Integration Section: (a)

Section Type: rcjrs

## Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Primary 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  $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $ef_u = 0.009$

Number of directions,  $NoDir = 1$

Fiber orientations,  $bi: 0.00^\circ$

Number of layers,  $NL = 1$

Radius of rounding corners,  $R = 40.00$

## Stepwise Properties

Bending Moment,  $M = -7.0400E+006$

Shear Force,  $V_2 = -1995.365$

Shear Force,  $V_3 = -1.4564234E-013$

Axial Force,  $F = -14177.47$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{l,com} = 1137.257$

-Middle:  $As_{l,mid} = 402.1239$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{l,ten,jacket} = 829.3805$

-Compression:  $As_{l,com,jacket} = 829.3805$

-Middle:  $As_{l,mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{l,ten,core} = 307.8761$

-Compression:  $As_{l,com,core} = 307.8761$

-Middle:  $As_{l,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.00270555$   
 $u = y + p = 0.00270555$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00270555$  ((4.29), Biskinis Phd))  
 $M_y = 2.6204E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3528.173  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.1390E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 14177.47$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.7968E+014$

Calculation of Yielding Moment  $M_y$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.8029545E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 311.2112$   
 $d = 707.00$   
 $y = 0.214783$   
 $A = 0.00962586$   
 $B = 0.0051813$   
with  $p_t = 0.00402142$   
 $p_c = 0.00402142$   
 $p_v = 0.00142194$   
 $N = 14177.47$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.4829079E-005$   
with  $f_c' (12.3, (ACI 440)) = 33.35516$   
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 400.00$   
 $h = 750.00$   
 $A_g = 300000.00$   
From (12.9), ACI 440:  $k_a = 0.14679369$   
 $g = p_t + p_c + p_v = 0.00946477$   
 $r_c = 40.00$   
 $A_e / A_c = 0.51607158$   
Effective FRP thickness,  $t_f = N L * t * \cos(b_1) = 1.00$   
effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.21210318$   
 $A = 0.00935205$   
 $B = 0.00502021$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b / d$

Inadequate Lap Length with  $l_b / d = 0.30$

- Calculation of  $p$  -



From table 10-8:  $p = 0.00$

with:

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

shear control ratio  $V_{yE}/V_{CoIE} = 0.19671905$

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

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

$t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00761619$

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.

$NUD = 14177.47$

$A_g = 300000.00$

$f_{cE} = (f_{c,jacket} \cdot \text{Area}_{jacket} + f_{c,core} \cdot \text{Area}_{core}) / \text{section\_area} = 33.00$

$f_{yIE} = (f_{y,ext\_Long\_Reinf} \cdot \text{Area}_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot \text{Area}_{int\_Long\_Reinf}) / \text{Area}_{Tot\_Long\_Rein} = 555.56$

$f_{yIE} = (f_{y,ext\_Trans\_Reinf} \cdot s_1 + f_{y,int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$

$\rho_l = \text{Area}_{Tot\_Long\_Rein} / (b \cdot d) = 0.00946477$

$b = 400.00$

$d = 707.00$

$f_{cE} = 33.00$

-----  
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

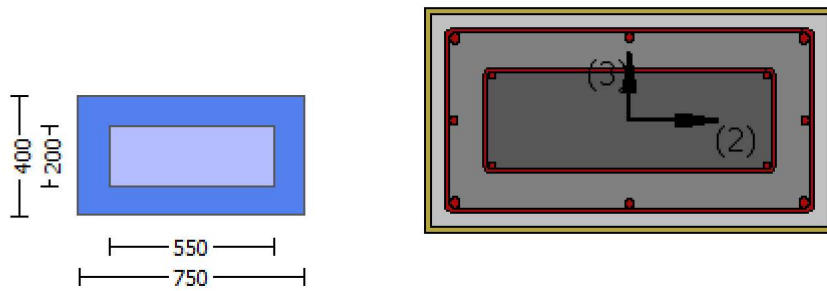
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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,  $\gamma = 0.90$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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

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

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

#####

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,  $L = 3000.00$

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $ef_u = 0.009$

Number of directions,  $NoDir = 1$

Fiber orientations,  $\theta_i$ : 0.00°  
Number of layers, NL = 1  
Radius of rounding corners, R = 40.00

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a$  = -7.0400E+006  
Shear Force,  $V_a$  = -1995.365  
EDGE -B-  
Bending Moment,  $M_b$  = 1.0488E+006  
Shear Force,  $V_b$  = 1995.365  
BOTH EDGES  
Axial Force,  $F$  = -14177.47  
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  
Mean Diameter of Tension Reinforcement,  $D_{bL,ten}$  = 16.80

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 1.1000E+006$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{Col0} = 1.1000E+006$   
 $V_{Col} = 1.1000E+006$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.02956278

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

= 1 (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa ((22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 1.0488E+006$   
 $V_u = 1995.365$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 14177.47$   
 $A_g = 300000.00$   
From ((11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 559706.147$   
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  $Col1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s2} = 88467.249$  is calculated for core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 463792.00  
 $f = 0.95$ , for fully-wrapped sections  
 $w_f/sf = 1$  (FRP strips adjacent to one another).  
In ((11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,  
where  $a$  is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function  $V_f(\theta_i)$ , is implemented for every different fiber orientation  $\theta_i$ ,

as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $\theta = b1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$ , with:  
total thickness per orientation,  $t_{f1} = NL * t / \text{NoDir} = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 707.00  
 $f_{fe} ((11-5), \text{ACI } 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
with  $f_u = 0.009$   
From (11-11), ACI 440:  $V_s + V_f \leq 797164.595$   
 $b_w = 400.00$

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  $\theta = 1.1916124E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00040308$  ((4.29), Biskinis Phd))  
 $M_y = 2.6204E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 525.6338  
From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} * E_c * I_g = 1.1390E+014$   
factor = 0.30  
 $A_g = 300000.00$   
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$   
 $N = 14177.47$   
 $E_c * I_g = E_c_{\text{jacket}} * I_{g_{\text{jacket}}} + E_c_{\text{core}} * I_{g_{\text{core}}} = 3.7968E+014$

Calculation of Yielding Moment  $M_y$

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

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 2.8029545E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$   
 $d = 707.00$   
 $y = 0.214783$   
 $A = 0.00962586$   
 $B = 0.0051813$   
with  $p_t = 0.00402142$   
 $p_c = 0.00402142$   
 $p_v = 0.00142194$   
 $N = 14177.47$   
 $b = 400.00$   
 $\mu = 0.06082037$   
 $y_{\text{comp}} = 1.4829079E-005$   
with  $f_c^*$  (12.3, (ACI 440)) = 33.35516  
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 400.00$   
 $h = 750.00$   
 $A_g = 300000.00$   
From (12.9), ACI 440:  $k_a = 0.14679369$   
 $g = p_t + p_c + p_v = 0.00946477$   
 $r_c = 40.00$   
 $A_e / A_c = 0.51607158$   
Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b1) = 1.00$   
effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.21210318$   
 $A = 0.00935205$

B = 0.00502021  
with Es = 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: (b)

## Calculation No. 6

column C1, Floor 1

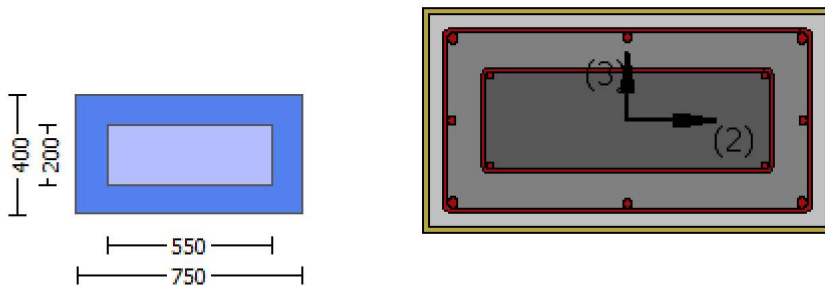
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

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,  $\gamma = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

```

Existing Column
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
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 = 1.0435
Element Length,  $L = 3000.00$ 
Primary 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  $l_o/l_{ou,min} = 0.30$ 
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness,  $t = 1.00$ 
Tensile Strength,  $f_{fu} = 840.00$ 
Tensile Modulus,  $E_f = 82000.00$ 
Elongation,  $\epsilon_{fu} = 0.009$ 
Number of directions,  $N_{oDir} = 1$ 
Fiber orientations,  $b_i: 0.00^\circ$ 
Number of layers,  $N_L = 1$ 
Radius of rounding corners,  $R = 40.00$ 
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = 3.4586346E-031$ 
EDGE -B-
Shear Force,  $V_b = -3.4586346E-031$ 
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:  $A_{sl,mid} = 402.1239$ 
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Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.14265244$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 121055.918$ 
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.8158E+008$ 
 $M_{u1+} = 1.8158E+008$ , 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
 $M_{u1-} = 1.8158E+008$ , 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

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.8158\text{E}+008$$

$M_{u2+} = 1.8158\text{E}+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 1.8158\text{E}+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $M_{u1+}$

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

$$\phi_u = 1.7255512\text{E}-005$$

$$M_u = 1.8158\text{E}+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$\phi_{co} (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01006403$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.01006403$$

$$\phi_{we} ((5.4c), \text{TB DY}) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.02692906$$

where  $\phi_f = a_f * \phi_f^* * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00266667$$

$$b_w = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\phi_{fy} = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.005$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L^* t \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f,f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

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

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

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

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

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

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

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

$$\phi_{psh, \min} * f_{ywe} = \text{Min}(\phi_{psh, x} * f_{ywe}, \phi_{psh, y} * f_{ywe}) = 1.64062$$

Expression ((5.4d), TB DY) 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)

$$\phi_{psh, x} * f_{ywe} = \phi_{psh1} * f_{ywe1} + \phi_{ps2} * f_{ywe2} = 1.64062$$

$$\phi_{ps1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

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

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 = 3.23907  
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 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00243499  
c = confinement factor = 1.0435

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
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 = 389.0139

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

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
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 = 389.0139

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  $fsv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.0500703$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.0500703$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc$  (5A.2, TBDY) = 34.43547  
 $cc$  (5A.5, TBDY) = 0.00243499  
 $c$  = confinement factor = 1.0435  
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05941729$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05941729$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02100943$

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

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

---->  
 $su$  (4.9) = 0.16886055  
 $Mu = MRc$  (4.14) = 1.8158E+008  
 $u = su$  (4.1) = 1.7255512E-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:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = shear\_factor \cdot Max(cu, cc) = 0.01006403$

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

From (5.4b), TBDY:  $cu = 0.01006403$

where ((5.4c), TBDY) =  $ase \cdot sh_{min} \cdot fy_{we} / f_{ce} + Min(fx, fy) = 0.02692906$

where  $f = af \cdot pf \cdot f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$fx = 0.02504965$   
 $af = 0.38744444$

$b = 750.00$   
 $h = 400.00$

From EC8 A4.4.3(6),  $pf = 2tf/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$fy = 0.04491794$

af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A4.4.3(6), pf = 2tf/bw = 0.005  
bw = 400.00  
effective stress from (A.35), ff,e = 765.1636

R = 40.00  
Effective FRP thickness, tf = NL\*t\*Cos(b1) = 1.00  
fu,f = 840.00  
Ef = 82000.00  
u,f = 0.015  
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) = 1.64062  
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 = 1.64062  
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 = 3.23907  
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 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00243499  
c = confinement factor = 1.0435

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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 fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with 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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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) = 0.16886055
Mu = MRc (4.14) = 1.8158E+008
u = su (4.1) = 1.7255512E-005

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu2+

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

$$u = 1.7255512E-005$$

$$Mu = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01006403$$

$$\phi_{we} ((5.4c), TBDY) = \alpha \cdot \phi_u \cdot \min(f_{ywe}/f_{ce} + \min(\phi_x, \phi_y)) = 0.02692906$$

where  $\phi = \alpha \cdot \phi_u \cdot f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_x = 0.02504965$$

$$\alpha_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$\alpha_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL \cdot t \cdot \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f,f} = 0.015$$

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

$$\alpha_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\phi_{sh,min} \cdot F_{ywe} = \text{Min}(\phi_{sh,x} \cdot F_{ywe}, \phi_{sh,y} \cdot F_{ywe}) = 1.64062$$

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

$$\phi_{sh,x} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 1.64062$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$$

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

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

$$h_1 = 400.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$$

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

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

$$h_2 = 200.00$$

$$\phi_{sh,y} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.23907$$

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

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

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

$h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $No \text{ stirups, } ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$

$ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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

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

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

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

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

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

with  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 389.0139$

with  $Es1 = (Es\_jacket \cdot Asl, ten, jacket + Es\_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$

$ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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

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

$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

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.

$y2, sh2, ft2, fy2$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 389.0139$

with  $Es2 = (Es\_jacket \cdot Asl, com, jacket + Es\_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.00140044$   
 $shv = 0.0044814$

$ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$

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

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

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

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

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

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

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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  $Esv = (Es\_jacket \cdot Asl, mid, jacket + Es\_mid \cdot Asl, mid, core) / Asl, mid = 200000.00$

$1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.0500703$

$2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.0500703$

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

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05941729$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05941729$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $w_e ((5.4c), TBDY) = a_{se} * sh_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$

$u, f = 0.015$   
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, \min \cdot F_{ywe} = \text{Min}(psh, x \cdot F_{ywe}, psh, y \cdot F_{ywe}) = 1.64062$   
 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)

$psh, x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.0020944$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00026808$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh, y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$A_{sec} = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lo, \min = lb/ld = 0.30$   
 $su1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs, \text{jacket} \cdot A_{sl, \text{ten, jacket}} + fs, \text{core} \cdot A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 389.0139$   
 with  $Es1 = (Es, \text{jacket} \cdot A_{sl, \text{ten, jacket}} + Es, \text{core} \cdot A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lo, \min = lb/lb, \min = 0.30$

$su_2 = 0.4 \cdot esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 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.  
 with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 389.0139$   
 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.  
 with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.0500703$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.0500703$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05941729$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05941729$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.16886055$

$\mu_u = MR_c (4.14) = 1.8158E+008$

$u = su (4.1) = 1.7255512E-005$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

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

$V_{Col0} = 848607.437$

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

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

= 1 (normal-weight concrete)

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



$M/Vd = 2.00$   
 $\mu_u = 3.5345895E-012$   
 $\mu_v = 3.4586346E-031$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
 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  $\text{Col1} = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $\text{Col2} = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 234192.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $w_f/s_f = 1$  (FRP strips adjacent to one another).  
 In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,  
 where  $a$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta = \theta_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 357.00  
 $f_{fe} ((11-5), \text{ACI } 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $b_w = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 848607.437$   
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_n l \cdot V_{\text{ColO}}$   
 $V_{\text{ColO}} = 848607.437$   
 $k_n l = 1$  (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).

$\lambda = 1$  (normal-weight concrete)  
 Mean concrete strength:  $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 3.5345895E-012$   
 $\mu_v = 3.4586346E-031$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
 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  $\text{Col1} = 1.00$   
 $s/d = 0.3125$

$V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f((11-3)-(11.4), ACI 440) = 234192.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $wf/sf = 1$  (FRP strips adjacent to one another).  
 In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
 where  $a$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$ , with:  
 total thickness per orientation,  $tf_1 = NL \cdot t / NoDir = 1.00$   
 $df_v = d$  (figure 11.2, ACI 440) = 357.00  
 $ffe((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 750.00$

-----  
 -----  
 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,  $\phi = 0.90$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Jacket  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 Existing Column  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 #####  
 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 = 1.0435  
 Element Length,  $L = 3000.00$

Primary 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  $l_o/l_{o,min} = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $\epsilon_{fu} = 0.009$   
 Number of directions,  $NoDir = 1$   
 Fiber orientations,  $b_i = 0.00^\circ$   
 Number of layers,  $NL = 1$   
 Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = 2.9582284E-031$   
 EDGE -B-  
 Shear Force,  $V_b = -2.9582284E-031$   
 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:  $As_{l,com} = 1137.257$   
   -Middle:  $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19671905$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$   
 with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 3.7261E+008$   
 $Mu_{1+} = 3.7261E+008$ , 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  
 $Mu_{1-} = 3.7261E+008$ , 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  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 3.7261E+008$   
 $Mu_{2+} = 3.7261E+008$ , 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  
 $Mu_{2-} = 3.7261E+008$ , 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:  
 $\phi_u = 8.5888248E-006$   
 $M_u = 3.7261E+008$

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) = 0.01006403
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01006403
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.02692906
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
-----
fx = 0.02504965
af = 0.38744444
b = 750.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00266667
bw = 750.00
effective stress from (A.35), ffe = 800.0873
-----
fy = 0.04491794
af = 0.38744444
b = 400.00
h = 750.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.005
bw = 400.00
effective stress from (A.35), ffe = 765.1636
-----
R = 40.00
Effective FRP thickness, tf = NL*t*cos(b1) = 1.00
fu,f = 840.00
Ef = 82000.00
u,f = 0.015
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) = 1.64062
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 = 1.64062
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 = 3.23907
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

```

$fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$   
 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  $fs_1 = (fs_{jacket} * Asl_{ten, jacket} + fs_{core} * Asl_{ten, core}) / Asl_{ten} = 389.0139$   
 with  $Es_1 = (Es_{jacket} * Asl_{ten, jacket} + Es_{core} * Asl_{ten, core}) / Asl_{ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl_{com, jacket} + fs_{core} * Asl_{com, core}) / Asl_{com} = 389.0139$   
 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.  
 $y_v, sh_v, ft_v, fy_v$ , 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  $Es_v = (Es_{jacket} * Asl_{mid, jacket} + Es_{mid} * Asl_{mid, core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.04740567$   
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.04740567$   
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 0.01676222$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.05824278$   
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.05824278$   
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 0.02059413$

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

--->

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

--->

$s_u(4.9) = 0.15682678$

$\mu_u = M_{Rc}(4.14) = 3.7261E+008$

$u = s_u(4.1) = 8.5888248E-006$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u1}$ -

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

$u = 8.5888248E-006$

$\mu_u = 3.7261E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $\alpha_{cu}$ :  $\alpha_{cu}^* = \text{shear\_factor} * \text{Max}(\alpha_{cu}, \alpha_{cc}) = 0.01006403$

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

From (5.4b), TBDY:  $\alpha_{cu} = 0.01006403$

$\alpha_{we}((5.4c), TBDY) = \alpha_{se} * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(\alpha_{fx}, \alpha_{fy}) = 0.02692906$

where  $f = \alpha_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\alpha_{fx} = 0.02504965$

$\alpha_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$\alpha_{fy} = 0.04491794$

$\alpha_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.005$

$bw = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{f,f} = 0.015$

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

$\alpha_{se1} = 0.12601038$

$bo\_1 = 690.00$

$ho\_1 = 340.00$

$bi2\_1 = 1.1834E+006$

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

$bo\_2 = 542.00$

$ho\_2 = 192.00$

```

bi2_2 = 661256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.64062
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 = 1.64062
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 = 3.23907
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 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,tens,jacket + fs,core*Asl,tens,core)/Asl,tens = 389.0139
with Es1 = (Es,jacket*Asl,tens,jacket + Es,core*Asl,tens,core)/Asl,tens = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,comp,jacket + fs,core*Asl,comp,core)/Asl,comp = 389.0139
with Es2 = (Es,jacket*Asl,comp,jacket + Es,core*Asl,comp,core)/Asl,comp = 200000.00
yv = 0.00140044
shv = 0.0044814

```

$f_{tv} = 466.8167$   
 $f_{yv} = 389.0139$   
 $s_{uv} = 0.00512$   
 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  $y_v$ ,  $sh_v, f_{tv}, f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, f_{t1}, f_{y1}$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = (f_{s,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 389.0139$   
 with  $E_{sv} = (E_{s,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.04740567$   
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.04740567$   
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.05824278$   
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.05824278$   
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u (4.9) = 0.15682678$

$M_u = M_{Rc} (4.14) = 3.7261E+008$

$u = s_u (4.1) = 8.5888248E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $M_{u2+}$

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

$u = 8.5888248E-006$

$M_u = 3.7261E+008$

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  $c_u$ :  $c_u^* = shear\_factor * Max(c_u, cc) = 0.01006403$

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

From (5.4b), TBDY:  $c_u = 0.01006403$

$w_e ((5.4c), TBDY) = a_s * sh_{min} * f_{ywe} / f_{ce} + Min(f_x, f_y) = 0.02692906$

where  $f = a_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$



af = 0.38744444  
b = 750.00  
h = 400.00  
From EC8 A4.4.3(6), pf =  $2t_f/bw = 0.00266667$   
bw = 750.00  
effective stress from (A.35), ff,e = 800.0873

fy = 0.04491794  
af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A4.4.3(6), pf =  $2t_f/bw = 0.005$   
bw = 400.00  
effective stress from (A.35), ff,e = 765.1636

R = 40.00  
Effective FRP thickness, tf =  $NL \cdot t \cdot \cos(b1) = 1.00$   
fu,f = 840.00  
Ef = 82000.00  
u,f = 0.015  
ase ((5.4d), TBDY) =  $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.12601038$   
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\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.64062  
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 = 1.64062  
ps1 (external) =  $(Ash1 \cdot h1/s1) / A_{sec} = 0.0020944$   
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) =  $(Ash2 \cdot h2/s2) / A_{sec} = 0.00026808$   
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.23907  
ps1 (external) =  $(Ash1 \cdot h1/s1) / A_{sec} = 0.00392699$   
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) =  $(Ash2 \cdot h2/s2) / A_{sec} = 0.00073723$   
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 = 694.45  
fce = 33.00  
From ((5.A5), TBDY), TBDY: cc = 0.00243499  
c = confinement factor = 1.0435  
y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,  
For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 389.0139$   
with  $Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 389.0139$   
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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$   
with  $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.04740567$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04740567$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01676222$   
and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05824278$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05824278$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02059413$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

-----  
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:

$$\mu = 8.5888248 \times 10^{-6}$$

$$\mu_2 = 3.7261 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$\nu = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$\alpha_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_2: \mu_2 = \text{shear\_factor} * \text{Max}(\mu_1, \alpha_0) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu_1 = 0.01006403$$

$$\mu_1 \text{ ((5.4c), TBDY)} = \alpha_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_{fx}, \mu_{fy}) = 0.02692906$$

where  $\mu_f = \alpha_f * \rho_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_{fx} = 0.02504965$$

$$\alpha_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\mu_{fy} = 0.04491794$$

$$\alpha_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\mu_{u,f} = 0.015$$

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

$$\alpha_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

$$b_{i2,1} = 1.1834 \times 10^{-6}$$

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 1.64062$$

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

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.23907  
 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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00243499

c = confinement factor = 1.0435

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

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 = 389.0139

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

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 = 389.0139

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  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 389.0139$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.04740567$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.04740567$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 34.43547$   
 $c_c \text{ (5A.5, TBDY)} = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.05824278$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.05824278$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$\mu_u \text{ (4.9)} = 0.15682678$

$\mu_u = M_{Rc} \text{ (4.14)} = 3.7261E+008$

$u = \mu_u \text{ (4.1)} = 8.5888248E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.2627E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627E+006$

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

$V_{Col0} = 1.2627E+006$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.3795529E-012$

$V_u = 2.9582284E-031$

$d = 0.8 \cdot h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 98297.73$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 463792.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $wf/sf = 1$  (FRP strips adjacent to one another).  
In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
where  $a$  is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function  $V_f( , )$ , is implemented for every different fiber orientation  $a_i$ ,  
as well as for 2 crack directions,  $= 45^\circ$  and  $= -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $\theta = b1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:  
total thickness per orientation,  $tf1 = NL \cdot t / NoDir = 1.00$   
 $dfv = d$  (figure 11.2, ACI 440) = 707.00  
 $ffe ((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
with  $f_u = 0.009$   
From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.2627E+006$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$   
 $V_{Col0} = 1.2627E+006$   
 $knl = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.3795529E-012$   
 $V_u = 2.9582284E-031$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$   
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  $Col1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s2} = 98297.73$  is calculated for core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 463792.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $wf/sf = 1$  (FRP strips adjacent to one another).  
In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
where  $a$  is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function  $V_f( , )$ , is implemented for every different fiber orientation  $a_i$ ,  
as well as for 2 crack directions,  $= 45^\circ$  and  $= -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $\theta = b1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:  
total thickness per orientation,  $tf1 = NL \cdot t / NoDir = 1.00$   
 $dfv = d$  (figure 11.2, ACI 440) = 707.00  
 $ffe ((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$

fe = 0.004, from (11.6a), ACI 440  
with fu = 0.009  
From (11-11), ACI 440: Vs + Vf <= 915872.391  
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,  $\gamma = 0.90$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
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,  $L = 3000.00$   
Primary 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  $l_b/l_d = 0.30$   
FRP Wrapping Data  
Type: Carbon  
Dry properties (design values)  
Thickness,  $t = 1.00$   
Tensile Strength,  $f_{fu} = 840.00$   
Tensile Modulus,  $E_f = 82000.00$   
Elongation,  $\epsilon_{fu} = 0.009$   
Number of directions,  $N_{oDir} = 1$   
Fiber orientations,  $b_i: 0.00^\circ$   
Number of layers,  $N_L = 1$   
Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

Bending Moment,  $M = -3.8976464E-011$   
Shear Force,  $V_2 = 1995.365$   
Shear Force,  $V_3 = 1.4564234E-013$   
Axial Force,  $F = -14177.47$   
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,  $DbL = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.00203008$

$u = y + p = 0.00203008$

- Calculation of  $y$  -

$y = (My * Ls / 3) / E_{eff} = 0.00203008$  ((4.29), Biskinis Phd))

$My = 1.3155E+008$

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

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.2399E+013$

$factor = 0.30$

$Ag = 300000.00$

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

$N = 14177.47$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 1.0800E+014$

Calculation of Yielding Moment  $My$

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

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

$y_{ten} = 5.6359183E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$

$d = 357.00$

$y = 0.22662123$

$A = 0.01016692$

$B = 0.00577058$

with  $pt = 0.00424746$

$pc = 0.00424746$

$p_v = 0.00150186$

$N = 14177.47$

$b = 750.00$

$" = 0.12044818$

$y_{comp} = 2.7804373E-005$

with  $fc^*$  (12.3, (ACI 440)) = 33.35499

$fc = 33.00$

$fl = 0.77176471$

$b = 750.00$

$h = 400.00$

$Ag = 300000.00$

From (12.9), ACI 440:  $ka = 0.14671972$

$g = pt + pc + p_v = 0.00999678$

$rc = 40.00$

$A_e / A_c = 0.51581153$

Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.00$

effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$

$f_u = 0.009$

$E_f = 82000.00$



$E_c = 26999.444$   
 $y = 0.22402532$   
 $A = 0.00987772$   
 $B = 0.00560044$   
with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00$

with:

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

shear control ratio  $V_y E / V_{Col} E = 0.14265244$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00393687$

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.

$NUD = 14177.47$

$A_g = 300000.00$

$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 33.00$

$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein =$

$555.56$

$f_{yE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$

$\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.00999678$

$b = 750.00$

$d = 357.00$

$f_{cE} = 33.00$

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

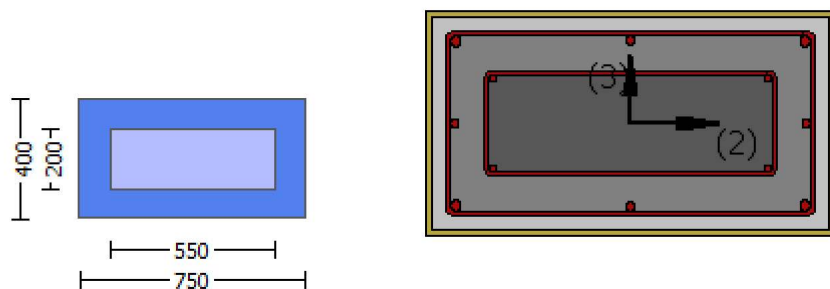
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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

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

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

#####

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,  $L = 3000.00$

Primary 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  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $e_{fu} = 0.009$   
 Number of directions,  $NoDir = 1$   
 Fiber orientations,  $bi: 0.00^\circ$   
 Number of layers,  $NL = 1$   
 Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

EDGE -A-  
 Bending Moment,  $M_a = 4.7677845E-010$   
 Shear Force,  $V_a = -1.4564234E-013$   
 EDGE -B-  
 Bending Moment,  $M_b = -3.8976464E-011$   
 Shear Force,  $V_b = 1.4564234E-013$   
 BOTH EDGES  
 Axial Force,  $F = -14177.47$   
 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:  $As_{mid} = 402.1239$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 776632.031$   
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 776632.031$   
 $V_{Col} = 776632.031$   
 $knl = 1.00$   
 $displacement\_ductility\_demand = 0.00$

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:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 3.8976464E-011$   
 $V_u = 1.4564234E-013$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 14177.47$   
 $A_g = 300000.00$   
 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:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 234192.00$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $\theta$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

$$\text{orientation 1: } \theta_1 = \theta_1 + 90^\circ = 90.00$$

$$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|), \text{ with:}$$

$$\text{total thickness per orientation, } t_{f1} = N_L * t / N_{\text{Dir}} = 1.00$$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 357.00$$

$$f_{fe}((11-5), \text{ACI 440}) = 328.00$$

$$E_f = 82000.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.009$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 797164.595$$

$$b_w = 750.00$$

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  $\theta = 2.3933076E-021$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00203008 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.3155E+008$$

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

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 3.2399E+013$$

$$\text{factor} = 0.30$$

$$A_g = 300000.00$$

$$\text{Mean concrete strength: } f'_c = (f'_c_{\text{jacket}} * A_{\text{jacket}} + f'_c_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$$

$$N = 14177.47$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 1.0800E+014$$

Calculation of Yielding Moment  $M_y$

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

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

$$y_{\text{ten}} = 5.6359183E-006$$

$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / d)^{2/3}) = 311.2112$$

$$d = 357.00$$

$$y = 0.22662123$$

$$A = 0.01016692$$

$$B = 0.00577058$$

$$\text{with } p_t = 0.00424746$$

$$p_c = 0.00424746$$

$$p_v = 0.00150186$$

$$N = 14177.47$$

$$b = 750.00$$

$$\mu = 0.12044818$$

$$y_{\text{comp}} = 2.7804373E-005$$

$$\text{with } f'_c * (12.3, (\text{ACI 440})) = 33.35499$$

$$f_c = 33.00$$

$$f_l = 0.77176471$$

$$b = 750.00$$

$h = 400.00$   
 $A_g = 300000.00$   
 From (12.9), ACI 440:  $k_a = 0.14671972$   
 $g = p_t + p_c + p_v = 0.00999678$   
 $rc = 40.00$   
 $A_e/A_c = 0.51581153$   
 Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.22402532$   
 $A = 0.00987772$   
 $B = 0.00560044$   
 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: (b)

## Calculation No. 8

column C1, Floor 1

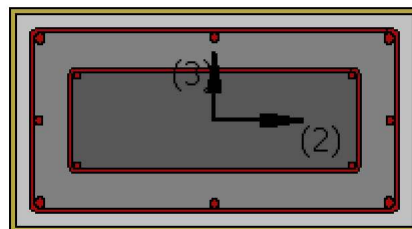
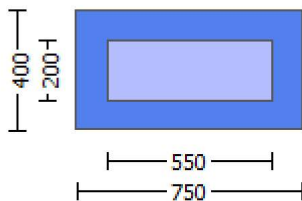
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

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,  $\gamma = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

Primary 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  $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $\epsilon_{fu} = 0.009$

Number of directions,  $N_{oDir} = 1$

Fiber orientations,  $b_i: 0.00^\circ$

Number of layers,  $N_L = 1$

Radius of rounding corners,  $R = 40.00$

### Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 3.4586346E-031$

EDGE -B-

Shear Force,  $V_b = -3.4586346E-031$

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:  $As_{l,com} = 1137.257$

-Middle:  $Asl_{mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $Ve/Vr = 0.14265244$

Member Controlled by Flexure ( $Ve/Vr < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $Ve = (M_{pr1} + M_{pr2})/l_n = 121055.918$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.8158E+008$

$Mu_{1+} = 1.8158E+008$ , 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

$Mu_{1-} = 1.8158E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.8158E+008$

$Mu_{2+} = 1.8158E+008$ , 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

$Mu_{2-} = 1.8158E+008$ , 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:

$\phi_u = 1.7255512E-005$

$M_u = 1.8158E+008$

with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $\phi_{cu}$ :  $\phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01006403$

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

From (5.4b), TBDY:  $\phi_{cu} = 0.01006403$

$\phi_{we} ((5.4c), TBDY) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.02692906$

where  $\phi_f = a_f * \phi_{pf} * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_{fx} = 0.02504965$

$a_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A.4.4.3(6),  $\phi_{pf} = 2t_f/b_w = 0.00266667$

$b_w = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$\phi_{fy} = 0.04491794$

$a_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A.4.4.3(6),  $\phi_{pf} = 2t_f/b_w = 0.005$

$b_w = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = N L * t * \text{Cos}(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{,f} = 0.015$

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

$a_{se1} = 0.12601038$

$b_{o\_1} = 690.00$

$ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 1.64062$   
 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)

$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.0020944$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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.

with  $fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 389.0139$   
 with  $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 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.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.0500703$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.0500703$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.05941729$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.05941729$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.01006403$   
 $w_e ((5.4c), TBDY) = a_{se} \cdot s_{h,min} \cdot f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = a_f \cdot p_f \cdot f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_u, f = 840.00$   
 $E_f = 82000.00$   
 $u, f = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$   
 $p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1} \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2} \cdot ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir,1} \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir,2} \cdot ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$

```

sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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,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 = 389.0139
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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,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/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
    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,min = lb/lb = 0.30
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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) = 0.16886055

```

$$\begin{aligned} \mu_u &= M_{Rc} (4.14) = 1.8158E+008 \\ u &= s_u (4.1) = 1.7255512E-005 \end{aligned}$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2+}$

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

$$\begin{aligned} u &= 1.7255512E-005 \\ \mu_u &= 1.8158E+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 750.00 \\ d &= 357.00 \\ d' &= 43.00 \\ v &= 0.00124684 \\ N &= 11016.808 \\ f_c &= 33.00 \end{aligned}$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, c_o) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01006403$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00266667$$

$$b_w = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.005$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

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

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

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

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

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

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

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.64062$$

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)

$$p_{sh\_x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.64062$$

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

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

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

$$h1 = 400.00$$

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

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

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

$$h2 = 200.00$$

$$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.23907$$

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

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

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

$$h1 = 750.00$$

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

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

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

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

$l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $yv, shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 389.0139$   
 with  $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.0500703$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu2$ -

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

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $we ((5.4c), TBDY) = ase * sh,min*fywe/fce + Min(fx, fy) = 0.02692906$   
 where  $f = af*pf*ffe/fce$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)  
 -----  
 $fx = 0.02504965$   
 $af = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $ffe = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.005$   
 $b_w = 400.00$   
 effective stress from (A.35),  $f_{f,e} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h_1 = 400.00$   
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h_1 = 750.00$   
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $su_1 = 0.4 \cdot esu1_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,  
 For calculation of  $esu1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered

characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{s1} = (f_{sjacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 389.0139$   
with  $E_{s1} = (E_{sjacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{s2} = (f_{sjacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 389.0139$   
with  $E_{s2} = (E_{sjacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
characteristic value  $f_{syv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{sjacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 389.0139$   
with  $E_{sv} = (E_{sjacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$   
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0500703$   
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0500703$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.01770442$   
and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05941729$   
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05941729$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02100943$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$



Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

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

$V_{Col0} = 848607.437$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.5345895E-012$

$\nu_u = 3.4586346E-031$

$d = 0.8 * h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

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:

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 234192.00$

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L * t / N_{Dir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 357.00

$f_{fe} \text{ ((11-5), ACI 440)} = 328.00$

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$b_w = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 848607.437$

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

$V_{Col0} = 848607.437$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.5345895E-012$

Vu = 3.4586346E-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 = 555.56  
s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 234192.00

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3)  $\sin \theta + \cos \theta$  is replaced with  $(\cot \theta + \cot \alpha) \sin \alpha$  which is more a generalised expression, where  $\theta$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(  $\theta$  ,  $\alpha$  ), is implemented for every different fiber orientation  $\alpha_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = \theta_1 + 90^\circ = 90.00$

Vf = Min(|Vf(45,  $\theta_1$ )|, |Vf(-45,  $\theta_1$ )|), with:

total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.00$

dfv = d (figure 11.2, ACI 440) = 357.00

ffe ((11-5), ACI 440) = 328.00

Ef = 82000.00

fe = 0.004, from (11.6a), ACI 440

with fu = 0.009

From (11-11), ACI 440: Vs + Vf <= 915872.391

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,  $\phi = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

```

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
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 = 1.0435
Element Length,  $L = 3000.00$ 
Primary 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  $l_o/l_{ou,min} = 0.30$ 
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness,  $t = 1.00$ 
Tensile Strength,  $f_{fu} = 840.00$ 
Tensile Modulus,  $E_f = 82000.00$ 
Elongation,  $e_{fu} = 0.009$ 
Number of directions,  $NoDir = 1$ 
Fiber orientations,  $b_i: 0.00^\circ$ 
Number of layers,  $NL = 1$ 
Radius of rounding corners,  $R = 40.00$ 
-----

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force,  $V_a = 2.9582284E-031$ 
EDGE -B-
Shear Force,  $V_b = -2.9582284E-031$ 
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:  $As_{l,com} = 1137.257$ 
-Middle:  $As_{l,mid} = 402.1239$ 
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19671905$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$ 
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 3.7261E+008$ 
 $Mu_{1+} = 3.7261E+008$ , 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
 $Mu_{1-} = 3.7261E+008$ , 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
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 3.7261E+008$ 
 $Mu_{2+} = 3.7261E+008$ , 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
 $Mu_{2-} = 3.7261E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

```

## Calculation of Mu1+

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

$$\mu = 8.5888248E-006$$

$$Mu = 3.7261E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01006403$$

$$\mu_e \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.02692906$$

where  $\mu = a_f * \mu_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\mu_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\mu_{f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 1.64062$$

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

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 550.00$

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00243499

c = confinement factor = 1.0435

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

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 = 389.0139

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

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 = 389.0139

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04740567$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.04740567$$

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

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.43547$$

$$cc (5A.5, TBDY) = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05824278$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05824278$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.15682678$$

$$\mu_u = M_{Rc} (4.14) = 3.7261E+008$$

$$u = su (4.1) = 8.5888248E-006$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u1}$ -

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

$$u = 8.5888248E-006$$

$$\mu_u = 3.7261E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01006403$$

$$we ((5.4c), TBDY) = ase * sh_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$$

where  $f = af * pf * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$af = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2tf/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } ff_e = 800.0873$$

$$f_y = 0.04491794$$

$$af = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2tf/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } ff_e = 765.1636$$

$R = 40.00$   
 Effective FRP thickness,  $t_f = N_L * t * \cos(b_1) = 1.00$   
 $f_u, f = 840.00$   
 $E_f = 82000.00$   
 $u, f = 0.015$   
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi_2_1 = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi_2_2 = 661256.00$   
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.64062$   
 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)

$psh, x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 1.64062$   
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir\_2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$psh, y * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 3.23907$   
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir\_2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

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

$lo/lo_{u, \min} = l_b / l_d = 0.30$

$su_1 = 0.4 * esu_1_{\text{nominal}} ((5.5), TBDY) = 0.032$

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

with  $fs_1 = (f_{s, \text{jacket}} * A_{sl, \text{ten, jacket}} + f_{s, \text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 389.0139$

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

$y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 389.0139$   
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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 389.0139$   
with  $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.04740567$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.04740567$   
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.01676222$   
and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.05824278$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.05824278$   
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.02059413$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.15682678$   
 $Mu = MR_c (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

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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:

$u = 8.5888248E-006$   
 $Mu = 3.7261E+008$   
-----

with full section properties:  
 $b = 400.00$



$d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
 Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\alpha = 0.01006403$   
 $\alpha_{we} ((5.4c), TBDY) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = \alpha * \rho_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $\alpha_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $\rho_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $\alpha_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $\rho_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.12601038$   
 $\alpha_{se1} = 0.12601038$   
 $b_{o,1} = 690.00$   
 $h_{o,1} = 340.00$   
 $b_{i2,1} = 1.1834E+006$   
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$   
 $b_{o,2} = 542.00$   
 $h_{o,2} = 192.00$   
 $b_{i2,2} = 661256.00$

$\rho_{sh, \min} * F_{ywe} = \text{Min}(\rho_{sh, x} * F_{ywe}, \rho_{sh, y} * F_{ywe}) = 1.64062$   
 Expression ((5.4d), TBDY) for  $\rho_{sh, \min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\rho_{sh, x} * F_{ywe} = \rho_{sh1} * F_{ywe1} + \rho_{sh2} * F_{ywe2} = 1.64062$   
 $\rho_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 400.00$   
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 200.00$

$\rho_{sh, y} * F_{ywe} = \rho_{sh1} * F_{ywe1} + \rho_{sh2} * F_{ywe2} = 3.23907$   
 $\rho_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 750.00$   
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$

$s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 389.0139$   
 with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.30$   
 $su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 389.0139$   
 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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.  
 with  $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 389.0139$   
 with  $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (fs1 / f_c) = 0.04740567$   
 $2 = A_{sl,com} / (b * d) * (fs2 / f_c) = 0.04740567$   
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.01676222$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten} / (b * d) * (fs1 / f_c) = 0.05824278$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05824278$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

---->

$$s_u(4.9) = 0.15682678$$

$$\mu_u = M_{Rc}(4.14) = 3.7261E+008$$

$$u = s_u(4.1) = 8.5888248E-006$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2}$ -

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

$$u = 8.5888248E-006$$

$$\mu_u = 3.7261E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.01006403$$

$$\mu_{we}((5.4c), TBDY) = a_{se} * \text{sh}_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f,f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

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

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

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

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

$bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.64062$   
 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)

$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.0020944$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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.

with  $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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.

with  $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139$

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

$y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Esv = (Es\_jacket * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.04740567$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04740567$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05824278$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05824278$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $V_r = Min(V_{r1}, V_{r2}) = 1.2627E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627E+006$

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

$V_{Col0} = 1.2627E+006$

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

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $Mu = 2.3795529E-012$   
 $Vu = 2.9582284E-031$   
 $d = 0.8 * h = 600.00$   
 $Nu = 11016.808$   
 $Ag = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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 = 98297.73 is calculated for core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.56818182$$

Vf ((11-3)-(11.4), ACI 440) = 463792.00

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = 45^\circ$  and  $\theta = -45^\circ$

Vf = Min(|Vf(45, 1)|, |Vf(-45, a1)|), with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

dfv = d (figure 11.2, ACI 440) = 707.00

ffe ((11-5), ACI 440) = 328.00

$$E_f = 82000.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.009$$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$$b_w = 400.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.2627E+006$

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

$$V_{Col0} = 1.2627E+006$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\mu_u = 2.3795529E-012$$

$$\nu_u = 2.9582284E-031$$

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

$$N_u = 11016.808$$

$$A_g = 300000.00$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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 = 98297.73 is calculated for core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.56818182$$

$V_f((11-3)-(11.4), \text{ACI 440}) = 463792.00$

$f = 0.95$ , for fully-wrapped sections

$wf/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $tf1 = NL \cdot t / \text{NoDir} = 1.00$

$dfv = d$  (figure 11.2, ACI 440) = 707.00

$ffe((11-5), \text{ACI 440}) = 328.00$

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$b_w = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (b)  
Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at  $135^\circ$ )

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $e_{fu} = 0.009$

Number of directions,  $\text{NoDir} = 1$

Fiber orientations,  $b_i: 0.00^\circ$

Number of layers, NL = 1  
Radius of rounding corners, R = 40.00

#### Stepwise Properties

Bending Moment, M = 1.0488E+006  
Shear Force, V2 = 1995.365  
Shear Force, V3 = 1.4564234E-013  
Axial Force, F = -14177.47  
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

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.00040308$   
 $u = y + p = 0.00040308$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00040308$  ((4.29), Biskinis Phd))  
 $M_y = 2.6204E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 525.6338  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.1390E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 14177.47$   
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 3.7968E+014$

#### Calculation of Yielding Moment $M_y$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.8029545E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/d)^{2/3}) = 311.2112$   
 $d = 707.00$   
 $y = 0.214783$   
 $A = 0.00962586$   
 $B = 0.0051813$   
with  $pt = 0.00402142$   
 $pc = 0.00402142$   
 $pv = 0.00142194$   
 $N = 14177.47$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.4829079E-005$   
with  $fc' (12.3, (ACI 440)) = 33.35516$



$f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 400.00$   
 $h = 750.00$   
 $A_g = 300000.00$   
 From (12.9), ACI 440:  $k_a = 0.14679369$   
 $g = p_t + p_c + p_v = 0.00946477$   
 $r_c = 40.00$   
 $A_e/A_c = 0.51607158$   
 Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $\gamma = 0.21210318$   
 $A = 0.00935205$   
 $B = 0.00502021$   
 with  $E_s = 200000.00$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

- Calculation of  $p$  -

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  $V_y E / V_{col} E = 0.19671905$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00761619$

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  $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$  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.

$N_{UD} = 14177.47$

$A_g = 300000.00$

$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 33.00$

$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein =$

555.56

$f_{yE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$

$p_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.00946477$

$b = 400.00$

$d = 707.00$

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (b)

## Calculation No. 9

column C1, Floor 1

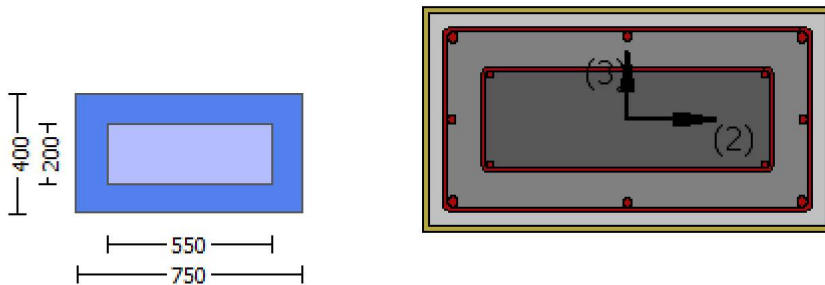
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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

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

New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
#####  
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,  $L = 3000.00$   
Primary 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  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
FRP Wrapping Data  
Type: Carbon  
Dry properties (design values)  
Thickness,  $t = 1.00$   
Tensile Strength,  $f_{fu} = 840.00$   
Tensile Modulus,  $E_f = 82000.00$   
Elongation,  $e_{fu} = 0.009$   
Number of directions,  $N_{oDir} = 1$   
Fiber orientations,  $b_i: 0.00^\circ$   
Number of layers,  $N_L = 1$   
Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -1.0982E+007$   
Shear Force,  $V_a = -3112.69$   
EDGE -B-  
Bending Moment,  $M_b = 1.6361E+006$   
Shear Force,  $V_b = 3112.69$   
BOTH EDGES  
Axial Force,  $F = -15947.314$   
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:  $As_{c,mid} = 4021239$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 948750.938$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n l \cdot V_{CoIO} = 948750.938$   
 $V_{CoI} = 948750.938$   
 $k_n l = 1.00$   
displacement\_ductility\_demand = 0.02136767

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

= 1 (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$   
MPa ((22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $M_u = 1.0982E+007$   
 $V_u = 3112.69$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 15947.314$   
 $A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 559706.147$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 88467.249$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

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

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 463792.00

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $\theta_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 707.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 797164.595$

$b_w = 400.00$

displacement\_ductility\_demand is calculated as  $\delta_u / y$

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

From analysis, chord rotation  $\theta = 5.7929149E-005$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00271107$  ((4.29), Biskinis Phd))

$M_y = 2.6257E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 3528.173

From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.1390E+014$

factor = 0.30

$A_g = 300000.00$

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

$N = 15947.314$

$E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 3.7968E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\delta_u$  and  $M_y$  according to Annex 7 -

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

$y_{\text{ten}} = 2.8044129E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b / I_d)^{2/3}) = 311.2112$

$d = 707.00$

$y = 0.21519134$

$A = 0.00964597$

$B = 0.00520141$

with  $p_t = 0.00402142$

$p_c = 0.00402142$

$p_v = 0.00142194$   
 $N = 15947.314$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.4823586E-005$   
 with  $f_c^* (12.3, (ACI 440)) = 33.35516$   
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 400.00$   
 $h = 750.00$   
 $A_g = 300000.00$   
 From (12.9), ACI 440:  $k_a = 0.14679369$   
 $g = p_t + p_c + p_v = 0.00946477$   
 $r_c = 40.00$   
 $A_e/A_c = 0.51607158$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.00$   
 effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.21218177$   
 $A = 0.00933798$   
 $B = 0.00502021$   
 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

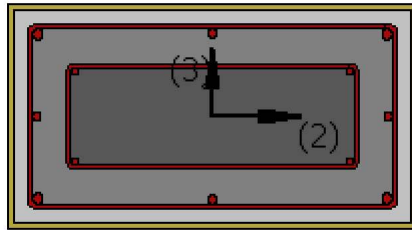
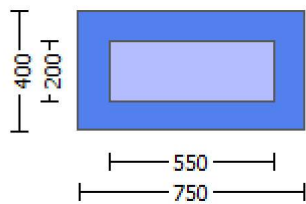
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

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,  $\gamma = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $ef_u = 0.009$

Number of directions,  $NoDir = 1$

Fiber orientations,  $bi: 0.00^\circ$

Number of layers,  $NL = 1$

Radius of rounding corners,  $R = 40.00$

## Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 3.4586346E-031$

EDGE -B-

Shear Force,  $V_b = -3.4586346E-031$

BOTH EDGES

Axial Force,  $F = -11016.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_{lt} = 0.00$

-Compression:  $As_{lc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{l,com} = 1137.257$

-Middle:  $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.14265244$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 121055.918$   
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.8158E+008$

$\mu_{u1+} = 1.8158E+008$ , 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

$\mu_{u1-} = 1.8158E+008$ , 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.8158E+008$

$\mu_{u2+} = 1.8158E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 1.8158E+008$ , 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  $\mu_{u1+}$

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

$\mu_u = 1.7255512E-005$

$\mu_u = 1.8158E+008$

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  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.01006403$

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

From (5.4b), TBDY:  $\mu_u = 0.01006403$

we ((5.4c), TBDY) =  $\alpha s_e * \text{sh}, \min(f_{ywe}/f_{ce} + \text{Min}(f_x, f_y)) = 0.02692906$

where  $f = \alpha f_p f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$

$\alpha f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.005$   
 $b_w = 400.00$   
 effective stress from (A.35),  $f_{f,e} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.64062$   
 $ps1$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h_1 = 400.00$   
 $ps2$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.23907$   
 $ps1$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h_1 = 750.00$   
 $ps2$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir\_2} \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c$  = confinement factor = 1.0435

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

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  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $su_1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered



characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{s1} = (f_{sjacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 389.0139$   
with  $E_{s1} = (E_{sjacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su2 = 0.4 \cdot esu2_{nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,  
For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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  $f_{s2} = (f_{sjacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 389.0139$   
with  $E_{s2} = (E_{sjacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv_{nominal}$  and  $yv, shv, ftv, fyv$ , it is considered  
characteristic value  $f_{syv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{sjacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 389.0139$   
with  $E_{sv} = (E_{sjacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$   
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0500703$   
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0500703$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.01770442$   
and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05941729$   
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05941729$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02100943$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu1$ -

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

$$\phi_u = 1.7255512E-005$$

$$\mu = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01006403$$

$$\phi_{we} ((5.4c), TBDY) = a_{se} * \phi_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.02692906$$

where  $\phi_f = a_f * \phi_{pf} * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\phi_{fy} = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f,f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\phi_{sh,min} * f_{ywe} = \text{Min}(\phi_{sh,x} * f_{ywe}, \phi_{sh,y} * f_{ywe}) = 1.64062$$

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)

$$\phi_{sh,x} * f_{ywe} = \phi_{sh1} * f_{ywe1} + \phi_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$$\phi_{sh,y} * f_{ywe} = \phi_{sh1} * f_{ywe1} + \phi_{sh2} * f_{ywe2} = 3.23907$$

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

$Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $No\ stirups, ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2\ (internal) = (Ash2 * h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $No\ stirups, ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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  $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$

$ft2 = 466.8167$   
 $fy2 = 389.0139$

$su2 = 0.00512$

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.

$y2, sh2, ft2, fy2$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 389.0139$

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

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.0500703$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.0500703$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05941729$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05941729$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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  $u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $w_e ((5.4c), TBDY) = a_{se} * sh_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.00$

$f_u, f = 840.00$   
 $E_f = 82000.00$   
 $u, f = 0.015$   
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, \min \cdot F_{ywe} = \text{Min}(psh, x \cdot F_{ywe}, psh, y \cdot F_{ywe}) = 1.64062$   
 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)

$psh, x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.0020944$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00026808$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh, y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$A_{sec} = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A5), TBDY),  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with  $\text{Shear\_factor} = 1.00$   
 $lo/lo, \min = lb/ld = 0.30$   
 $su1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs, \text{jacket} \cdot A_{sl, \text{ten, jacket}} + fs, \text{core} \cdot A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 389.0139$   
 with  $Es1 = (Es, \text{jacket} \cdot A_{sl, \text{ten, jacket}} + Es, \text{core} \cdot A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
 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 = 389.0139
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 Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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) = 0.16886055
Mu = MRc (4.14) = 1.8158E+008
u = su (4.1) = 1.7255512E-005

```

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

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

u = 1.7255512E-005  
Mu = 1.8158E+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) = 0.01006403
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01006403
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.02692906
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
-----
fx = 0.02504965
af = 0.38744444
b = 750.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00266667
bw = 750.00
effective stress from (A.35), ffe = 800.0873
-----
fy = 0.04491794
af = 0.38744444
b = 400.00
h = 750.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.005
bw = 400.00
effective stress from (A.35), ffe = 765.1636
-----
R = 40.00
Effective FRP thickness, tf = NL*t*cos(b1) = 1.00
fu,f = 840.00
Ef = 82000.00
u,f = 0.015
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) = 1.64062
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 = 1.64062
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 = 3.23907
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 = 694.45
fce = 33.00
From ((5A.5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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 = 389.0139
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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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

--->

$\mu_u$  (4.9) = 0.16886055

$\mu_u = M_{Rc}$  (4.14) = 1.8158E+008

$u = \mu_u$  (4.1) = 1.7255512E-005

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

$V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n I V_{ColO}$

$V_{ColO} = 848607.437$

$k_n = 1$  (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).

$f_c = 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.5345895E-012$

$V_u = 3.4586346E-031$

$d = 0.8h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

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:

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 234192.00

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(a)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $a = 45^\circ$  and  $a = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \min(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 357.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 848607.437$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$   
 $V_{Col0} = 848607.437$   
 $knl = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M / Vd = 2.00$   
 $M_u = 3.5345895E-012$   
 $V_u = 3.4586346E-031$   
 $d = 0.8 * h = 320.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
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:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 234192.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $w_f / s_f = 1$  (FRP strips adjacent to one another).  
In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,  
where  $a$  is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function  $V_f( , )$ , is implemented for every different fiber orientation  $a_i$ ,  
as well as for 2 crack directions,  $a = 45^\circ$  and  $a = -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $a_1 = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$ , with:  
total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 357.00  
 $f_{fe} ((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
with  $f_u = 0.009$   
From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 750.00$

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,  $\gamma = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

Primary 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  $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $\epsilon_{fu} = 0.009$

Number of directions,  $N_{oDir} = 1$

Fiber orientations,  $b_i: 0.00^\circ$

Number of layers,  $N_L = 1$

Radius of rounding corners,  $R = 40.00$

## Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = 2.9582284E-031$

EDGE -B-

Shear Force,  $V_b = -2.9582284E-031$

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:  $As_{l,com} = 1137.257$

-Middle:  $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19671905$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$   
 with  
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.7261\text{E}+008$   
 $\mu_{u1+} = 3.7261\text{E}+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $\mu_{u1-} = 3.7261\text{E}+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
 direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.7261\text{E}+008$   
 $\mu_{u2+} = 3.7261\text{E}+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
 which is defined for the the static loading combination  
 $\mu_{u2-} = 3.7261\text{E}+008$ , 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:  
 $\phi_u = 8.5888248\text{E}-006$   
 $\mu_u = 3.7261\text{E}+008$   
 -----

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\phi_c \text{ (5A.5, TBDY)} = 0.002$

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01006403$

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

From (5.4b), TBDY:  $\phi_u = 0.01006403$

we ((5.4c), TBDY) =  $a_{se} * \phi_{u,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.02692906$

where  $\phi_f = a_f * \phi_f^* f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

-----  
 $\phi_{fx} = 0.02504965$

$a_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A4.4.3(6),  $\phi_f = 2t_f/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

-----  
 $\phi_{fy} = 0.04491794$

$a_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A4.4.3(6),  $\phi_f = 2t_f/bw = 0.005$

$bw = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

-----  
 $R = 40.00$

Effective FRP thickness,  $t_f = N L^* t \cos(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{f} = 0.015$

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

$a_{se1} = 0.12601038$

$bo_1 = 690.00$

$ho_1 = 340.00$

$bi2_1 = 1.1834\text{E}+006$

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

$bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 1.64062$   
 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)

$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.0020944$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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.

with  $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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.

with  $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139$

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

$y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 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  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl\_mid,jacket + fs\_mid * Asl\_mid,core) / Asl\_mid = 389.0139$   
 with  $Esv = (Es\_jacket * Asl\_mid,jacket + Es\_mid * Asl\_mid,core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.04740567$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.04740567$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.05824278$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.05824278$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

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:

$u = 8.5888248E-006$   
 $Mu = 3.7261E+008$

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  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $we ((5.4c), TBDY) = ase * sh\_min * fy_{we} / fce + Min(fx, fy) = 0.02692906$   
 where  $f = af * pf * ffe / fce$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.00266667$   
 $b_w = 750.00$   
 effective stress from (A.35),  $f_{f,e} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.005$   
 $b_w = 400.00$   
 effective stress from (A.35),  $f_{f,e} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = N_L \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $b_{o,1} = 690.00$   
 $h_{o,1} = 340.00$   
 $b_{i2,1} = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $b_{o,2} = 542.00$   
 $h_{o,2} = 192.00$   
 $b_{i2,2} = 661256.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$   
 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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 1.64062$   
 $p_{sh1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 400.00$   
 $p_{sh2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.23907$   
 $p_{sh1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 750.00$   
 $p_{sh2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A5), TBDY), TBDY:  $c_c = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$

```

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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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 = 389.0139
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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008
u = su (4.1) = 8.5888248E-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:

$\mu = 8.5888248E-006$

$\mu_u = 3.7261E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \phi) = 0.01006403$

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

From (5.4b), TBDY:  $\mu_u = 0.01006403$

$\mu_{ue}$  ((5.4c), TBDY) =  $a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_{fx}, \mu_{fy}) = 0.02692906$

where  $\mu_f = a_f * \mu_{pf} * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\mu_{fx} = 0.02504965$

$a_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A.4.4.3(6),  $\mu_{pf} = 2t_f/b_w = 0.00266667$

$b_w = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$\mu_{fy} = 0.04491794$

$a_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A.4.4.3(6),  $\mu_{pf} = 2t_f/b_w = 0.005$

$b_w = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = N L * t * \cos(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{f} = 0.015$

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

$a_{se1} = 0.12601038$

$b_{o,1} = 690.00$

$h_{o,1} = 340.00$

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

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

$b_{o,2} = 542.00$

$h_{o,2} = 192.00$

$b_{i2,2} = 661256.00$

$\mu_{psh,min} * f_{ywe} = \text{Min}(\mu_{psh,x} * f_{ywe}, \mu_{psh,y} * f_{ywe}) = 1.64062$

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)

$\mu_{psh,x} * f_{ywe} = \mu_{psh1} * f_{ywe1} + \mu_{ps2} * f_{ywe2} = 1.64062$

$\mu_{ps1}$  (external) =  $(A_{sh1} * h_1/s_1)/A_{sec} = 0.0020944$

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

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

$h1 = 400.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00026808$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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

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

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

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

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

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

with  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 389.0139$

with  $Es1 = (Es\_jacket \cdot Asl, ten, jacket + Es\_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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

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

$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

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.

$y2, sh2, ft2, fy2$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 389.0139$

with  $Es2 = (Es\_jacket \cdot Asl, com, jacket + Es\_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$

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

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

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

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04740567$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04740567$

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

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc}$  (5A.2, TBDY) = 34.43547

$cc$  (5A.5, TBDY) = 0.00243499

$c$  = confinement factor = 1.0435

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05824278$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05824278$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.15682678

$Mu = MR_c$  (4.14) = 3.7261E+008

$u = su$  (4.1) = 8.5888248E-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:

$u = 8.5888248E-006$

$Mu = 3.7261E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01006403$

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

From (5.4b), TBDY:  $cu = 0.01006403$

$w_e$  ((5.4c), TBDY) =  $ase \cdot sh_{min} \cdot fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.02692906$

where  $f = af \cdot pf \cdot f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$fx = 0.02504965$

$af = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A4.4.3(6),  $pf = 2tf/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$fy = 0.04491794$

$af = 0.38744444$

$b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $ff,e = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $tf = NL*t*Cos(b1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u,f = 0.015$   
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = Max(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$

$psh,min*Fywe = Min(psh,x*Fywe, psh,y*Fywe) = 1.64062$   
 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)

$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 1.64062$   
 $ps1 (external) = (Ash1*h1/s1)/A_{sec} = 0.0020944$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.23907$   
 $ps1 (external) = (Ash1*h1/s1)/A_{sec} = 0.00392699$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$A_{sec} = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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  $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 389.0139$

```

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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 fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with 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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008
u = su (4.1) = 8.5888248E-006

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.2627\text{E}+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627\text{E}+006$

$Vr1 = VCol \text{ ((10.3), ASCE 41-17)} = knl * VCol0$

$VCol0 = 1.2627E+006$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.3795529E-012$

$\nu_u = 2.9582284E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 98297.73$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.56818182$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 463792.00$

$f = 0.95$ , for fully-wrapped sections

$wf/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $tf1 = NL * t / NoDir = 1.00$

$dfv = d$  (figure 11.2, ACI 440) = 707.00

$ffe \text{ ((11-5), ACI 440)} = 328.00$

$E_f = 82000.00$

$fe = 0.004$ , from (11.6a), ACI 440

with  $fu = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$bw = 400.00$

Calculation of Shear Strength at edge 2,  $Vr2 = 1.2627E+006$

$Vr2 = VCol \text{ ((10.3), ASCE 41-17)} = knl * VCol0$

$VCol0 = 1.2627E+006$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.3795529E-012$

$\nu_u = 2.9582284E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$   
 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  $Col1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s2} = 98297.73$  is calculated for core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 463792.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $wf/sf = 1$  (FRP strips adjacent to one another).  
 In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,  
 where  $a$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(, )$ , is implemented for every different fiber orientation  $a_i$ ,  
 as well as for 2 crack directions,  $a = 45^\circ$  and  $a = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $a_1 = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = NL * t / \text{NoDir} = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 707.00  
 $f_{fe} ((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $b_w = 400.00$

-----  
 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,  $\phi = 0.90$   
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 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,  $L = 3000.00$   
 Primary 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  $l_b/l_d = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $e_{fu} = 0.009$   
 Number of directions,  $NoDir = 1$   
 Fiber orientations,  $bi: 0.00^\circ$   
 Number of layers,  $NL = 1$   
 Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

Bending Moment,  $M = 7.4177612E-010$   
 Shear Force,  $V2 = -3112.69$   
 Shear Force,  $V3 = -2.2719624E-013$   
 Axial Force,  $F = -15947.314$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{c,com} = 1137.257$   
   -Middle:  $As_{mid} = 402.1239$   
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,jacket} = 829.3805$   
   -Compression:  $As_{c,com,jacket} = 829.3805$   
   -Middle:  $As_{mid,jacket} = 402.1239$   
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,core} = 307.8761$   
   -Compression:  $As_{c,com,core} = 307.8761$   
   -Middle:  $As_{mid,core} = 0.00$   
 Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.0274056$   
 $u = y + p = 0.0274056$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00203441$  ((4.29), Biskinis Phd))  
 $M_y = 1.3183E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.2399E+013$   
 $factor = 0.30$   
 $A_g = 300000.00$   
 Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 15947.314$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 1.0800E+014$

Calculation of Yielding Moment  $M_y$



Calculation of  $\gamma$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 5.6388532\text{E-}006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25*f_y*(l_b/d)^{2/3}) = 311.2112$   
 $d = 357.00$   
 $y = 0.22702375$   
 $A = 0.01018816$   
 $B = 0.00579182$   
with  $p_t = 0.00424746$   
 $p_c = 0.00424746$   
 $p_v = 0.00150186$   
 $N = 15947.314$   
 $b = 750.00$   
 $\alpha = 0.12044818$   
 $y_{\text{comp}} = 2.7794074\text{E-}005$   
with  $f_c^* (12.3, \text{ACI } 440)) = 33.35499$   
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 750.00$   
 $h = 400.00$   
 $A_g = 300000.00$   
From (12.9), ACI 440:  $k_a = 0.14671972$   
 $g = p_t + p_c + p_v = 0.00999678$   
 $r_c = 40.00$   
 $A_e/A_c = 0.51581153$   
Effective FRP thickness,  $t_f = N L^* t^* \cos(b_1) = 1.00$   
effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.22410833$   
 $A = 0.00986286$   
 $B = 0.00560044$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.02537119$

with:

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

shear control ratio  $V_y E / V_{CoI} E = 0.14265244$

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

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

$t = s_1 + s_2 + 2*t_f/bw*(f_{fe}/f_s) = 0.00393687$

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

where  $f = 2*t_f/bw$  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.

$NUD = 15947.314$

$A_g = 300000.00$

$f_c E = (f_{c\_jacket}*Area\_jacket + f_{c\_core}*Area\_core)/section\_area = 33.00$

$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 555.56$   
 $f_{yE} = (f_{y\_ext\_Trans\_Reinf} \cdot s1 + f_{y\_int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 555.56$   
 $\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.00999678$   
 $b = 750.00$   
 $d = 357.00$   
 $f_{cE} = 33.00$

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

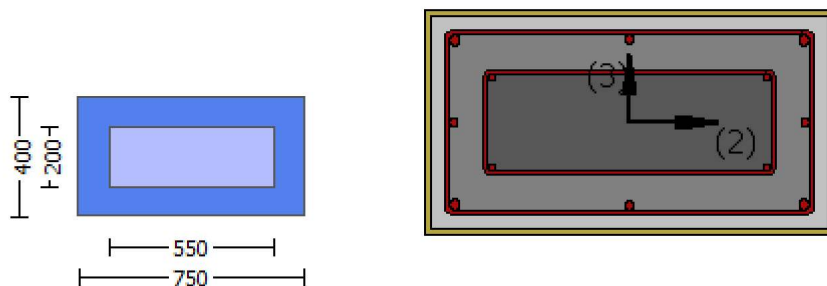
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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,  $\gamma = 0.90$

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

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of  $\gamma$  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  
 New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
 #####  
 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,  $L = 3000.00$   
 Primary 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  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $ef_u = 0.009$   
 Number of directions,  $NoDir = 1$   
 Fiber orientations,  $bi: 0.00^\circ$   
 Number of layers,  $NL = 1$   
 Radius of rounding corners,  $R = 40.00$   
 -----

Stepwise Properties  
 -----  
 EDGE -A-  
 Bending Moment,  $M_a = 7.4177612E-010$   
 Shear Force,  $V_a = -2.2719624E-013$   
 EDGE -B-  
 Bending Moment,  $M_b = -5.8822499E-011$   
 Shear Force,  $V_b = 2.2719624E-013$   
 BOTH EDGES  
 Axial Force,  $F = -15947.314$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{l,ten} = 1137.257$   
   -Compression:  $As_{l,com} = 1137.257$   
   -Middle:  $As_{l,mid} = 402.1239$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$   
 -----  
 -----

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 776982.499$

Vn ((10.3), ASCE 41-17) = knl\*VCol0 = 776982.499

VCol = 776982.499

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 = 25.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 7.4177612E-010

Vu = 2.2719624E-013

d = 0.8\*h = 320.00

Nu = 15947.314

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 = 500.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 234192.00

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sin + cos is replaced with (cot + cota)sina which is more a generalised expression,  
where is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,  
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.

orientation 1: 1 = b1 + 90° = 90.00

Vf = Min(|Vf(45, 1)|, |Vf(-45,a1)|), with:

total thickness per orientation, tf1 = NL\*t/NoDir = 1.00

dfv = d (figure 11.2, ACI 440) = 357.00

ffe ((11-5), ACI 440) = 328.00

Ef = 82000.00

fe = 0.004, from (11.6a), ACI 440

with fu = 0.009

From (11-11), ACI 440: Vs + Vf <= 797164.595

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 = 1.0055897E-020

y = (My\*Ls/3)/Eleff = 0.00203441 ((4.29),Biskinis Phd))

My = 1.3183E+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 = 3.2399E+013

factor = 0.30

Ag = 300000.00

Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 33.00

N = 15947.314

$$E_c I_g = E_{c\_jacket} I_{g\_jacket} + E_{c\_core} I_{g\_core} = 1.0800E+014$$

Calculation of Yielding Moment  $M_y$

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

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

$$y_{ten} = 5.6388532E-006$$

$$\text{with } ((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$$

$$d = 357.00$$

$$y = 0.22702375$$

$$A = 0.01018816$$

$$B = 0.00579182$$

$$\text{with } p_t = 0.00424746$$

$$p_c = 0.00424746$$

$$p_v = 0.00150186$$

$$N = 15947.314$$

$$b = 750.00$$

$$" = 0.12044818$$

$$y_{comp} = 2.7794074E-005$$

$$\text{with } f_c^* (12.3, \text{ACI 440}) = 33.35499$$

$$f_c = 33.00$$

$$f_l = 0.77176471$$

$$b = 750.00$$

$$h = 400.00$$

$$A_g = 300000.00$$

$$\text{From } (12.9), \text{ACI 440: } k_a = 0.14671972$$

$$g = p_t + p_c + p_v = 0.00999678$$

$$r_c = 40.00$$

$$A_e / A_c = 0.51581153$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.00$$

$$\text{effective strain from } (12.5) \text{ and } (12.12), \epsilon_{fe} = 0.004$$

$$f_u = 0.009$$

$$E_f = 82000.00$$

$$E_c = 26999.444$$

$$y = 0.22410833$$

$$A = 0.00986286$$

$$B = 0.00560044$$

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

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: 3

Integration Section: (a)

**Calculation No. 12**

column C1, Floor 1

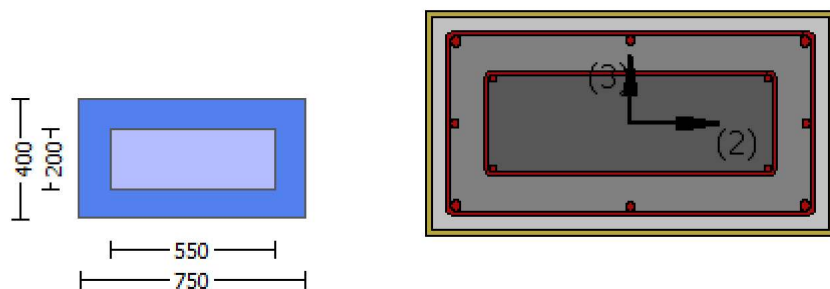
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

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,  $\gamma = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

Primary 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  $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $\epsilon_{fu} = 0.009$

Number of directions,  $NoDir = 1$

Fiber orientations,  $bi: 0.00^\circ$

Number of layers,  $NL = 1$

Radius of rounding corners,  $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 3.4586346E-031$

EDGE -B-

Shear Force,  $V_b = -3.4586346E-031$

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,  $V_e/V_r = 0.14265244$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 121055.918$  with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.8158E+008$

$\mu_{u1+} = 1.8158E+008$ , 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

$\mu_{u1-} = 1.8158E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.8158E+008$

$\mu_{u2+} = 1.8158E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 1.8158E+008$ , 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  $\mu_{u1+}$

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

$\phi_u = 1.7255512E-005$

$\mu_u = 1.8158E+008$

with full section properties:

$b = 750.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00124684$

$N = 11016.808$

$f_c = 33.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01006403$

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

From (5.4b), TBDY:  $c_u = 0.01006403$

$w_e$  ((5.4c), TBDY) =  $a_s * \text{sh\_min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$

where  $f = a_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$

$a_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$

$a_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.005$

$bw = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{,f} = 0.015$

$a_s$  ((5.4d), TBDY) =  $(a_{s1} * A_{ext} + a_{s2} * A_{int}) / A_{sec} = 0.12601038$

$a_{s1} = 0.12601038$

$bo\_1 = 690.00$

$ho\_1 = 340.00$

$bi2\_1 = 1.1834E+006$

$a_{s2} = \text{Max}(a_{s1}, a_{s2}) = 0.12601038$

$bo\_2 = 542.00$

$ho\_2 = 192.00$

$bi2\_2 = 661256.00$

$p_{sh,min} * f_{ywe} = \text{Min}(p_{sh,x} * f_{ywe}, p_{sh,y} * f_{ywe}) = 1.64062$

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)

$p_{sh,x} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 1.64062$

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

$p_{sh,y} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 3.23907$

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 550.00$

$A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00243499$



```

c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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 = 389.0139
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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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

```

--->

$$s_u(4.9) = 0.16886055$$

$$M_u = M_{Rc}(4.14) = 1.8158E+008$$

$$u = s_u(4.1) = 1.7255512E-005$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $M_{u1}$ -

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

$$u = 1.7255512E-005$$

$$M_u = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$\phi_0(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01006403$$

$$\phi_{ue}((5.4c), TBDY) = a_{se} * \phi_{u,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.02692906$$

where  $\phi_f = a_f * \phi_{pf} * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.00266667$$

$$b_w = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\phi_{fy} = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.005$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

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

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

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

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

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

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

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

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 1.64062$$

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)

$psh\_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.0020944$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00026808$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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

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

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

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

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

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

with  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 389.0139$

with  $Es1 = (Es\_jacket \cdot Asl, ten, jacket + Es\_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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

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

$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

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

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 389.0139$

with  $Es2 = (Es\_jacket \cdot Asl, com, jacket + Es\_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$

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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.0500703$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.0500703$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01770442$   
 and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05941729$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05941729$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $we ((5.4c), TBDY) = ase * sh_{min} * fy_{we} / fce + \text{Min}(fx, fy) = 0.02692906$   
 where  $f = af * pf * ffe / fce$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)  
 -----  
 $fx = 0.02504965$   
 $af = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.00266667$

bw = 750.00  
effective stress from (A.35),  $f_{f,e} = 800.0873$

fy = 0.04491794  
af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
bw = 400.00  
effective stress from (A.35),  $f_{f,e} = 765.1636$

R = 40.00  
Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_f = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$   
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 1.64062$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.23907$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $su_1 = 0.4 \cdot esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 389.0139$   
with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
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  
 $lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 389.0139$   
with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
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  
 $lo/lou, min = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 389.0139$   
with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.0500703$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.0500703$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.01770442$   
and confined core properties:  
 $b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.05941729$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05941729$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.02100943$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)  
--->  
 $v < vs, y2$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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:

$$\mu = 1.7255512E-005$$

$$\mu = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01006403$$

$$\mu_e \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.02692906$$

where  $\mu = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.02504965$$

$$a_{se} = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{sh} = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\mu_y = 0.04491794$$

$$a_{se} = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{sh} = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\mu_{u,f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 1.64062$$

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

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 550.00$

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00243499

c = confinement factor = 1.0435

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

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 = 389.0139

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

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 = 389.0139

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



$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.0500703$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.0500703$$

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

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.43547$$

$$c_c (5A.5, TBDY) = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05941729$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05941729$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.16886055$$

$$M_u = M_{Rc} (4.14) = 1.8158E+008$$

$$u = s_u (4.1) = 1.7255512E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

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

$$V_{Col0} = 848607.437$$

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

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).

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

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

$$M/Vd = 2.00$$

$$M_u = 3.5345895E-012$$

$$V_u = 3.4586346E-031$$

$$d = 0.8 * h = 320.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

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

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:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

$$V_f ((11-3)-(11.4), ACI 440) = 234192.00$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

$wf/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $tf1 = NL \cdot t / \text{NoDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 357.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$bw = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 848607.437$

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

$V_{Col0} = 848607.437$

$knl = 1$  (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).

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

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

$M/Vd = 2.00$

$\mu_u = 3.5345895E-012$

$\nu_u = 3.4586346E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 11016.808$

$A_g = 300000.00$

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:

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 234192.00

$f = 0.95$ , for fully-wrapped sections

$wf/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $tf1 = NL \cdot t / \text{NoDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 357.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$bw = 750.00$

-----  
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

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Knowledge Factor,  $\gamma = 0.90$   
Mean strength values are used for both shear and moment calculations.  
Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

Primary 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  $l_o/l_{o,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $\epsilon_{fu} = 0.009$

Number of directions,  $N_{oDir} = 1$

Fiber orientations,  $b_i: 0.00^\circ$

Number of layers,  $N_L = 1$

Radius of rounding corners,  $R = 40.00$   
-----

#### Stepwise Properties

-----

At local axis: 2

EDGE -A-

Shear Force,  $V_a = 2.9582284E-031$

EDGE -B-

Shear Force,  $V_b = -2.9582284E-031$

BOTH EDGES

Axial Force,  $F = -11016.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_{lt} = 0.00$

-Compression:  $As_{lc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{l,com} = 1137.257$

-Middle:  $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.19671905$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.7261E+008$

$Mu_{1+} = 3.7261E+008$ , 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

$Mu_{1-} = 3.7261E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.7261E+008$

$Mu_{2+} = 3.7261E+008$ , 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

$Mu_{2-} = 3.7261E+008$ , 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:

$\phi_u = 8.5888248E-006$

$M_u = 3.7261E+008$

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  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01006403$

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

From (5.4b), TBDY:  $\phi_u = 0.01006403$

we ((5.4c), TBDY) =  $\phi_u^* * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.02692906$

where  $\phi = \phi_u^* * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.02504965$

$\phi_y = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.00266667$

$b_w = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$

$\phi_y = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.005$

$b_w = 400.00$

effective stress from (A.35),  $f_{f,e} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{,f} = 0.015$

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

$ase_1 = 0.12601038$

$bo_1 = 690.00$

$ho_1 = 340.00$

$bi_{2,1} = 1.1834E+006$

$ase_2 = \max(ase_1, ase_2) = 0.12601038$

$bo_2 = 542.00$

$ho_2 = 192.00$

$bi_{2,2} = 661256.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 1.64062$

$ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$

$A_{sh1} = A_{stir\_1} \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$

$A_{sh2} = A_{stir\_2} \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.23907$

$ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h_1 = 750.00$

$ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$

$A_{sh2} = A_{stir\_2} \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h_2 = 550.00$

$A_{sec} = 300000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$

$c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$lo/lo_{u,min} = l_b / l_d = 0.30$

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

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

with  $fs_1 = (f_{s,jacket} \cdot A_{s1,ten,jacket} + f_{s,core} \cdot A_{s1,ten,core}) / A_{s1,ten} = 389.0139$

with  $Es_1 = (E_{s,jacket} \cdot A_{s1,ten,jacket} + E_{s,core} \cdot A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

```

fy2 = 389.0139
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,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 = 389.0139
    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,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) = 0.04740567
    2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
    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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
    c = confinement factor = 1.0435
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
    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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008
u = su (4.1) = 8.5888248E-006

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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 Mu1-

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

u = 8.5888248E-006

Mu = 3.7261E+008

---

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha = \text{shear\_factor} * \text{Max}(\alpha_c, \alpha_s) = 0.01006403$$

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

$$\text{From (5.4b), TB DY: } \alpha_c = 0.01006403$$

$$\alpha_s ((5.4c), \text{TB DY}) = \alpha_s * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_{fx}, \alpha_{fy}) = 0.02692906$$

where  $\alpha = \alpha_s * \rho_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$\alpha_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$\alpha_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(\beta_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_f = 0.015$$

$$\alpha_s ((5.4d), \text{TB DY}) = (\alpha_{s1} * A_{ext} + \alpha_{s2} * A_{int}) / A_{sec} = 0.12601038$$

$$\alpha_{s1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

$$\alpha_{s2} = \text{Max}(\alpha_{s1}, \alpha_{s2}) = 0.12601038$$

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 1.64062$$

Expression ((5.4d), TB DY) 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)

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 3.23907$$

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

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

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

$$h_1 = 750.00$$

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

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

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

$$h_2 = 550.00$$

```

Asec = 300000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A.5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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 fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with 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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499

```



$c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05824278$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05824278$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

$\mu_u(4.9) = 0.15682678$   
 $\mu_u = M_{Rc}(4.14) = 3.7261E+008$   
 $u = \mu_u(4.1) = 8.5888248E-006$

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:

$u = 8.5888248E-006$   
 $\mu_u = 3.7261E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha_{co}(5A.5, TBDY) = 0.002$   
 Final value of  $\mu_{cu}$ :  $\mu_{cu} = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\mu_{cu} = 0.01006403$   
 $\mu_{we}((5.4c), TBDY) = \alpha_{se} * \text{sh,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = \alpha_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $\alpha_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.00266667$   
 $b_w = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $\alpha_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.005$   
 $b_w = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = N L * t * \text{Cos}(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{f,f} = 0.015$   
 $\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int})/A_{sec} = 0.12601038$   
 $\alpha_{se1} = 0.12601038$   
 $b_{o,1} = 690.00$   
 $h_{o,1} = 340.00$

$bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 1.64062$   
 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)

$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.0020944$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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.

with  $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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.

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008
u = su (4.1) = 8.5888248E-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 = 8.5888248E-006

Mu = 3.7261E+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) = 0.01006403

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

From (5.4b), TBDY: cu = 0.01006403

we ((5.4c), TBDY) = ase\* sh,min\*fywe/fce+Min( fx, fy) = 0.02692906  
where f = af\*pf\*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

fx = 0.02504965  
af = 0.38744444  
b = 750.00  
h = 400.00  
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00266667  
bw = 750.00  
effective stress from (A.35), ff,e = 800.0873

fy = 0.04491794  
af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.005  
bw = 400.00  
effective stress from (A.35), ff,e = 765.1636

R = 40.00  
Effective FRP thickness, tf = NL\*t\*cos(b1) = 1.00  
fu,f = 840.00  
Ef = 82000.00  
u,f = 0.015  
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) = 1.64062  
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 = 1.64062  
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 = 3.23907  
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 = 694.45  
fce = 33.00  
From ((5.A5), TBDY), TBDY: cc = 0.00243499  
c = confinement factor = 1.0435  
y1 = 0.00140044  
sh1 = 0.0044814

```

ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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 = 389.0139
    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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
    c = confinement factor = 1.0435
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
    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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008

```

$$u = su(4.1) = 8.5888248E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.2627E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627E+006$

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

$V_{Col0} = 1.2627E+006$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.3795529E-012$

$\mu_v = 2.9582284E-031$

$d = 0.8 * h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 98297.73$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.56818182$

$V_f((11-3)-(11.4), ACI 440) = 463792.00$

$f = 0.95$ , for fully-wrapped sections

$w_f/sf = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(, )$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $a = 45^\circ$  and  $a = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $a_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, a_1)|, |V_f(-45, a_1)|)$ , with:

total thickness per orientation,  $t_{f1} = NL * t / NoDir = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 707.00

$f_{fe}((11-5), ACI 440) = 328.00$

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.2627E+006$

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

$V_{Col0} = 1.2627E+006$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot Area\_jacket + f'_{c\_core} \cdot Area\_core) / Area\_section = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 2.3795529E-012$

$V_u = 2.9582284E-031$

$d = 0.8 \cdot h = 600.00$

$N_u = 11016.808$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 98297.73$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 463792.00

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression, where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 707.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$

$b_w = 400.00$

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

At local axis: 2

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

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\phi = 0.90$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 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,  $L = 3000.00$   
 Primary 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  $l_b/l_d = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $ε_{fu} = 0.009$   
 Number of directions,  $N_{oDir} = 1$   
 Fiber orientations,  $b_i: 0.00^\circ$   
 Number of layers,  $N_L = 1$   
 Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

Bending Moment,  $M = -1.0982E+007$   
 Shear Force,  $V_2 = -3112.69$   
 Shear Force,  $V_3 = -2.2719624E-013$   
 Axial Force,  $F = -15947.314$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 2676.637$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{l,com} = 1137.257$   
   -Middle:  $As_{l,mid} = 402.1239$   
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,jacket} = 829.3805$   
   -Compression:  $As_{l,com,jacket} = 829.3805$   
   -Middle:  $As_{l,mid,jacket} = 402.1239$   
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,core} = 307.8761$   
   -Compression:  $As_{l,com,core} = 307.8761$   
   -Middle:  $As_{l,mid,core} = 0.00$   
 Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.03271107$   
 $u = y + p = 0.03271107$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00271107 ((4.29), \text{Biskinis Phd})$



$M_y = 2.6257E+008$   
 $L_s = M/V$  (with  $L_s > 0.1*L$  and  $L_s < 2*L$ ) = 3528.173  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.1390E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 15947.314$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 3.7968E+014$

#### Calculation of Yielding Moment $M_y$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.8044129E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$   
 $d = 707.00$   
 $y = 0.21519134$   
 $A = 0.00964597$   
 $B = 0.00520141$   
 with  $p_t = 0.00402142$   
 $p_c = 0.00402142$   
 $p_v = 0.00142194$   
 $N = 15947.314$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.4823586E-005$   
 with  $f_c^*$  (12.3, (ACI 440)) = 33.35516  
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 400.00$   
 $h = 750.00$   
 $A_g = 300000.00$   
 From (12.9), ACI 440:  $k_a = 0.14679369$   
 $g = p_t + p_c + p_v = 0.00946477$   
 $r_c = 40.00$   
 $A_e / A_c = 0.51607158$   
 Effective FRP thickness,  $t_f = N L * t * \cos(b_1) = 1.00$   
 effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.21218177$   
 $A = 0.00933798$   
 $B = 0.00502021$   
 with  $E_s = 200000.00$

#### Calculation of ratio $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $I_b / I_d < 1$   
 shear control ratio  $V_y E / V_{col} O E = 0.19671905$   
 $d = d_{external} = 707.00$   
 $s = s_{external} = 0.00$   
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00761619$   
 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

$$h1 = 750.00$$

$$s1 = 100.00$$

$$\text{core: } s2 = Av2 \cdot h2 / (s2 \cdot Ag) = 0.00073723$$

$Av2 = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$$h2 = 550.00$$

$$s2 = 250.00$$

The term  $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$  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.

$$NUD = 15947.314$$

$$Ag = 300000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 33.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 555.56$$

$$f_{yIE} = (f_{y\_ext\_Trans\_Reinf} \cdot s1 + f_{y\_int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 555.56$$

$$\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.00946477$$

$$b = 400.00$$

$$d = 707.00$$

$$f_{cE} = 33.00$$

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

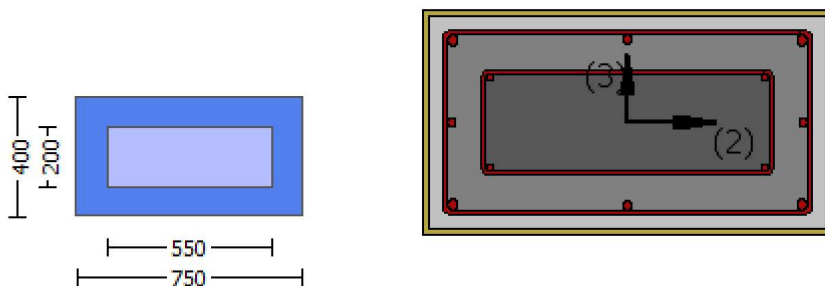
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $VR_d$

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,  $\gamma = 0.90$ 
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of  $\gamma$  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
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material: Steel Strength,  $f_s = f_{sm} = 555.56$ 
#####
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,  $L = 3000.00$ 
Primary 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  $l_o/l_{ou,min} = l_b/l_d = 0.30$ 
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness,  $t = 1.00$ 
Tensile Strength,  $f_{fu} = 840.00$ 
Tensile Modulus,  $E_f = 82000.00$ 
Elongation,  $\epsilon_{fu} = 0.009$ 
Number of directions,  $N_{oDir} = 1$ 
Fiber orientations,  $b_i: 0.00^\circ$ 
Number of layers,  $N_L = 1$ 
Radius of rounding corners,  $R = 40.00$ 
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment,  $M_a = -1.0982E+007$ 
Shear Force,  $V_a = -3112.69$ 
EDGE -B-
Bending Moment,  $M_b = 1.6361E+006$ 
Shear Force,  $V_b = 3112.69$ 
BOTH EDGES
Axial Force,  $F = -15947.314$ 

```

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:  $As_{mid} = 402.1239$

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

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 1.1003E+006$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 1.1003E+006$

$V_{CoI} = 1.1003E+006$

$k_n = 1.00$

displacement\_ductility\_demand = 0.04602302

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6361E+006$

$V_u = 3112.69$

$d = 0.8 \cdot h = 600.00$

$N_u = 15947.314$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 559706.147$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 88467.249$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

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

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 463792.00

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(, )$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $a = 45^\circ$  and  $a = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $a_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

$d_{fv} = d$  (figure 11.2, ACI 440) = 707.00

$f_{fe}$  ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_{e} = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.009$

From (11-11), ACI 440:  $V_s + V_f \leq 797164.595$

$b_w = 400.00$

displacement\_ductility\_demand is calculated as  $\delta / y$

- Calculation of  $\phi_y$  for END B -  
for rotation axis 3 and integ. section (b)

From analysis, chord rotation  $\theta = 1.8588678E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.0004039$  ((4.29), Biskinis Phd))  
 $M_y = 2.6257E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 525.6338  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.1390E+014$   
 $factor = 0.30$   
 $A_g = 300000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 15947.314$   
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 3.7968E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.8044129E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$   
 $d = 707.00$   
 $y = 0.21519134$   
 $A = 0.00964597$   
 $B = 0.00520141$   
with  $p_t = 0.00402142$   
 $p_c = 0.00402142$   
 $p_v = 0.00142194$   
 $N = 15947.314$   
 $b = 400.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.4823586E-005$   
with  $f_c' (12.3, (ACI 440)) = 33.35516$   
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 400.00$   
 $h = 750.00$   
 $A_g = 300000.00$   
From (12.9), ACI 440:  $k_a = 0.14679369$   
 $g = p_t + p_c + p_v = 0.00946477$   
 $r_c = 40.00$   
 $A_e / A_c = 0.51607158$   
Effective FRP thickness,  $t_f = N L * t * \cos(\theta_1) = 1.00$   
effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.21218177$   
 $A = 0.00933798$   
 $B = 0.00502021$   
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: (b)

## Calculation No. 14

column C1, Floor 1

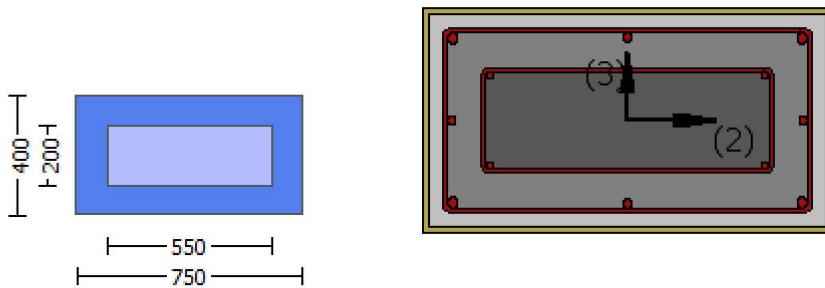
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

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,  $\gamma = 0.90$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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 = 1.0435
Element Length, L = 3000.00
Primary 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
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, $f_{fu}$ = 840.00
Tensile Modulus, $E_f$ = 82000.00
Elongation, $ε_{fu}$ = 0.009
Number of directions, NoDir = 1
Fiber orientations, $b_i$ : 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00
-----
Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force, $V_a$ = 3.4586346E-031
EDGE -B-
Shear Force, $V_b$ = -3.4586346E-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: $A_{sl,ten}$ = 1137.257
-Compression: $A_{sl,com}$ = 1137.257
-Middle: $A_{sl,mid}$ = 402.1239
-----
-----
Calculation of Shear Capacity ratio , $V_e/V_r$ = 0.14265244
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 121055.918$
with
$M_{pr1} = \text{Max}(\mu_{1+} , \mu_{1-}) = 1.8158\text{E}+008$
$\mu_{1+} = 1.8158\text{E}+008$ , 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
$\mu_{1-} = 1.8158\text{E}+008$ , 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
$M_{pr2} = \text{Max}(\mu_{2+} , \mu_{2-}) = 1.8158\text{E}+008$
$\mu_{2+} = 1.8158\text{E}+008$ , 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
$\mu_{2-} = 1.8158\text{E}+008$ , 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:
$\phi_u = 1.7255512\text{E}-005$
$\mu_u = 1.8158\text{E}+008$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01006403$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.01006403$$

$$\alpha_e ((5.4c), \text{TB DY}) = \alpha * \frac{\min(f_{ywe}/f_{ce}, \text{Min}(f_x, f_y))}{f_c} = 0.02692906$$

where  $f = \alpha * \rho_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$\alpha_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$\alpha_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_f = 0.015$$

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

$$\alpha_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i,2} = 661256.00$$

$$\rho_{sh, \min} * f_{ywe} = \text{Min}(\rho_{sh, x} * f_{ywe}, \rho_{sh, y} * f_{ywe}) = 1.64062$$

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

$$\rho_{sh, x} * f_{ywe} = \rho_{sh1} * f_{ywe1} + \rho_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$$\rho_{sh, y} * f_{ywe} = \rho_{sh1} * f_{ywe1} + \rho_{sh2} * f_{ywe2} = 3.23907$$

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

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

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

$$h_1 = 750.00$$

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

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

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



$$h_2 = 550.00$$

$$A_{sec} = 300000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.5), \text{TBDY}), \text{TBDY: } cc = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs_1 = (fs_{jacket} * Asl, \text{ten}, \text{jacket} + fs_{core} * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs_2 = (fs_{jacket} * Asl, \text{com}, \text{jacket} + fs_{core} * Asl, \text{com}, \text{core}) / Asl, \text{com} = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$su_v = 0.00512$$

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

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

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

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

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

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

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.0500703$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.0500703$$

$$v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.01770442$$

and confined core properties:

$$b = 690.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 34.43547$$

$$cc(5A.5, TBDY) = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su(4.9) = 0.16886055$$

$$Mu = MRc(4.14) = 1.8158E+008$$

$$u = su(4.1) = 1.7255512E-005$$

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:

$$u = 1.7255512E-005$$

$$Mu = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01006403$$

$$we((5.4c), TBDY) = ase * sh, min * fywe / fce + \text{Min}(fx, fy) = 0.02692906$$

where  $f = af * pf * ffe / fce$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$fx = 0.02504965$$

$$af = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2tf/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } ffe = 800.0873$$

$$fy = 0.04491794$$

$$af = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2tf/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } ffe = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } tf = NL * t * \text{Cos}(b1) = 1.00$$

$$fu, f = 840.00$$

$$Ef = 82000.00$$

$$u, f = 0.015$$

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

$$ase1 = 0.12601038$$

$$bo_1 = 690.00$$

$ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 1.64062$   
 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)

$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.0020944$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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.

with  $fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 389.0139$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 389.0139$   
 with  $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 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.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.0500703$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.0500703$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.05941729$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.05941729$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.01006403$   
 $w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int})/A_{sec} = 0.12601038$   
 $a_{se1} = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$   
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.64062$

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)

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (A_{sh1} * h_1/s_1)/A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps2 \text{ (internal)} = (A_{sh2} * h_2/s_2)/A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir\_2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (A_{sh1} * h_1/s_1)/A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps2 \text{ (internal)} = (A_{sh2} * h_2/s_2)/A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir\_2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$

```

sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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 = 389.0139
    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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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) = 0.16886055

```

$$\begin{aligned} \mu_u &= M_{Rc} (4.14) = 1.8158E+008 \\ u &= s_u (4.1) = 1.7255512E-005 \end{aligned}$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_u$

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

$$\begin{aligned} u &= 1.7255512E-005 \\ \mu_u &= 1.8158E+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 750.00 \\ d &= 357.00 \\ d' &= 43.00 \\ v &= 0.00124684 \\ N &= 11016.808 \\ f_c &= 33.00 \\ c_o (5A.5, TBDY) &= 0.002 \end{aligned}$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, c_o) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01006403$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00266667$$

$$b_w = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.005$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f,f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

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

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

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

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

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

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

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.64062$$

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)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.64062$$

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

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

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

$$h1 = 400.00$$

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

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

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

$$h2 = 200.00$$

$$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.23907$$

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

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

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

$$h1 = 750.00$$

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

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

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

$$h2 = 550.00$$

$$Asec = 300000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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



$l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 \cdot e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $f_{yv}$ , it is considered  
 characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1$ ,  $sh_1$ ,  $ft_1$ ,  $f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = (f_{sj\_jacket} \cdot A_{sl,mid,jacket} + f_{sj\_mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 389.0139$   
 with  $E_{sv} = (E_{sj\_jacket} \cdot A_{sl,mid,jacket} + E_{sj\_mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.0500703$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.0500703$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.05941729$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.05941729$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.02100943$

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

----

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

----

$su (4.9) = 0.16886055$   
 $Mu = MR_c (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} \cdot V_{ColO}$   
 $V_{ColO} = 848607.437$   
 $k_{nl} = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $Mu = 3.5345895E-012$   
 $Vu = 3.4586346E-031$   
 $d = 0.8 \cdot h = 320.00$   
 $Nu = 11016.808$   
 $Ag = 300000.00$   
 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:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 234192.00$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|), \text{ with:}$$

$$\text{total thickness per orientation, } t_{f1} = N_L * t / N_{\text{Dir}} = 1.00$$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 357.00$$

$$f_{fe}((11-5), \text{ACI 440}) = 328.00$$

$$E_f = 82000.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.009$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 915872.391$$

$$b_w = 750.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 848607.437$

$$V_{r2} = V_{\text{Col}}((10.3), \text{ASCE 41-17}) = k_n l * V_{\text{ColO}}$$

$$V_{\text{ColO}} = 848607.437$$

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

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\mu_u = 3.5345895E-012$$

$$V_u = 3.4586346E-031$$

$$d = 0.8 * h = 320.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

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

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:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 234192.00$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 357.00  
 $f_{fe} ((11-5), \text{ACI 440}) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $b_w = 750.00$

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,  $\gamma = 0.90$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:

Jacket

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

Existing Column

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

#####

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

Jacket

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

Existing Column

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

#####

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 = 1.0435

Element Length,  $L = 3000.00$

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $e_{fu} = 0.009$

Number of directions,  $\text{NoDir} = 1$

Fiber orientations,  $b_i: 0.00^\circ$

Number of layers, NL = 1  
Radius of rounding corners, R = 40.00

#### Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force, Va = 2.9582284E-031  
EDGE -B-  
Shear Force, Vb = -2.9582284E-031  
BOTH EDGES  
Axial Force, F = -11016.808  
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

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.19671905$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.7261\text{E}+008$   
 $\mu_{1+} = 3.7261\text{E}+008$ , 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  
 $\mu_{1-} = 3.7261\text{E}+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.7261\text{E}+008$   
 $\mu_{2+} = 3.7261\text{E}+008$ , 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  
 $\mu_{2-} = 3.7261\text{E}+008$ , 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  $\mu$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu = 8.5888248\text{E}-006$   
 $\mu_u = 3.7261\text{E}+008$

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  $\phi_c$ :  $\phi_c^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_{cc}) = 0.01006403$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_c = 0.01006403$   
 $\phi_{we}$  ((5.4c), TBDY) =  $a_s e^* \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.02692906$   
where  $\phi_f = a_f * \phi_{pf} * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)  
 $\phi_{fx} = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
From EC8 A.4.4.3(6),  $\phi_{pf} = 2t_f/bw = 0.00266667$

bw = 750.00  
effective stress from (A.35),  $f_{f,e} = 800.0873$

fy = 0.04491794  
af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
bw = 400.00  
effective stress from (A.35),  $f_{f,e} = 765.1636$

R = 40.00  
Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_f = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 661256.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$   
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 1.64062$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.23907$   
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

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  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $su_1 = 0.4 \cdot esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 389.0139$   
with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$   
and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 389.0139$   
with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
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.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 389.0139$   
with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.04740567$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.04740567$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.01676222$   
and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.05824278$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05824278$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.02059413$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)  
--->  
 $v < vs, y2$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

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:

$$\mu = 8.5888248E-006$$

$$Mu = 3.7261E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.01006403$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01006403$$

$$\mu_e \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.02692906$$

where  $\mu = a_f * \mu_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\mu_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\mu_{f} = 0.015$$

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

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

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

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

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

$$b_{o,2} = 542.00$$

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

$$b_{i2,2} = 661256.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 1.64062$$

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

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 1.64062$$

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

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

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

$$h_1 = 400.00$$

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

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

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

$$h_2 = 200.00$$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 550.00$

Asec = 300000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00243499

c = confinement factor = 1.0435

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

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 = 389.0139

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

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 = 389.0139

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



$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04740567$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.04740567$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01676222$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.43547$$

$$cc (5A.5, TBDY) = 0.00243499$$

$$c = \text{confinement factor} = 1.0435$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05824278$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05824278$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.15682678$$

$$\mu_u = M_{Rc} (4.14) = 3.7261E+008$$

$$u = su (4.1) = 8.5888248E-006$$

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:

$$u = 8.5888248E-006$$

$$\mu_u = 3.7261E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, cc) = 0.01006403$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_u = 0.01006403$$

$$\mu_u \text{ ((5.4c), TBDY) } = a_{se} * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$R = 40.00$   
 Effective FRP thickness,  $t_f = N_L * t * \cos(b_1) = 1.00$   
 $f_u, f = 840.00$   
 $E_f = 82000.00$   
 $u, f = 0.015$   
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.12601038$   
 $ase_1 = 0.12601038$   
 $bo_1 = 690.00$   
 $ho_1 = 340.00$   
 $bi_2_1 = 1.1834E+006$   
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.12601038$   
 $bo_2 = 542.00$   
 $ho_2 = 192.00$   
 $bi_2_2 = 661256.00$   
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 1.64062$   
 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)

$psh, x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 1.64062$   
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 400.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 200.00$

$psh, y * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 3.23907$   
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir,1} * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h_1 = 750.00$   
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00073723$   
 $A_{sh2} = A_{stir,2} * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$lo/lo_{u,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu_1_{nominal} = 0.08$

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1 / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 389.0139$

with  $Es_1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 389.0139$   
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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$   
with  $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.04740567$   
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.04740567$   
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 0.01676222$   
and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.05824278$   
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.05824278$   
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 0.02059413$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

-----  
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:

$u = 8.5888248E-006$   
 $Mu = 3.7261E+008$   
-----

with full section properties:

$b = 400.00$

$d = 707.00$   
 $d' = 43.00$   
 $v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
 Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\alpha_c = 0.01006403$   
 $\alpha_{ve} ((5.4c), TBDY) = \alpha^* \cdot \text{sh}_{\min} \cdot f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = \alpha^* \cdot p_f \cdot f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $\alpha_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f / b_w = 0.00266667$   
 $b_w = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $\alpha_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f / b_w = 0.005$   
 $b_w = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = N L^* t \cdot \cos(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{,f} = 0.015$   
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$   
 $\alpha_{se1} = 0.12601038$   
 $b_{o,1} = 690.00$   
 $h_{o,1} = 340.00$   
 $b_{i2,1} = 1.1834E+006$   
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$   
 $b_{o,2} = 542.00$   
 $h_{o,2} = 192.00$   
 $b_{i2,2} = 661256.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 1.64062$   
 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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 1.64062$   
 $p_{s1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$   
 No stirrups,  $n_{s,1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$   
 $A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$   
 No stirrups,  $n_{s,2} = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.23907$   
 $p_{s1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$   
 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,  $n_{s,2} = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$

```

s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5A5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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 fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with 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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278

```

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05824278$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02059413$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---->

$$s_u(4.9) = 0.15682678$$

$$M_u = M_{Rc}(4.14) = 3.7261E+008$$

$$u = s_u(4.1) = 8.5888248E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 1.2627E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627E+006$

$V_{r1} = V_{Col}((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$$V_{Col0} = 1.2627E+006$$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$M_u = 2.3795529E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 * h = 600.00$$

$$N_u = 11016.808$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 621900.694$$

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  $Col1 = 1.00$

$$s/d = 0.16666667$$

$V_{s2} = 98297.73$  is calculated for core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

$V_{s2}$  is multiplied by  $Col2 = 1.00$

$$s/d = 0.56818182$$

$$V_f((11-3)-(11.4), ACI 440) = 463792.00$$

$f = 0.95$ , for fully-wrapped sections

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,

where  $a$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(a, \theta)$ , is implemented for every different fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \min(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.00$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 707.00$$

$$f_{fe}((11-5), ACI 440) = 328.00$$

$$E_f = 82000.00$$

fe = 0.004, from (11.6a), ACI 440  
with fu = 0.009  
From (11-11), ACI 440: Vs + Vf <= 915872.391  
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.2627E+006  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 1.2627E+006  
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 = 33.00, but fc'^0.5 <= 8.3  
MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 2.3795529E-012  
Vu = 2.9582284E-031  
d = 0.8\*h = 600.00  
Nu = 11016.808  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 621900.694  
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 = 98297.73 is calculated for core, with:  
d = 440.00  
Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 1.00  
s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 463792.00  
f = 0.95, for fully-wrapped sections  
wf/sf = 1 (FRP strips adjacent to one another).  
In (11.3) sin + cos is replaced with (cot + cota)sina which is more a generalised expression,  
where is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,  
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.  
orientation 1: 1 = b1 + 90° = 90.00  
Vf = Min(|Vf(45, 1)|, |Vf(-45,a1)|), with:  
total thickness per orientation, tf1 = NL\*t/NoDir = 1.00  
dfv = d (figure 11.2, ACI 440) = 707.00  
ffe ((11-5), ACI 440) = 328.00  
Ef = 82000.00  
fe = 0.004, from (11.6a), ACI 440  
with fu = 0.009  
From (11-11), ACI 440: Vs + Vf <= 915872.391  
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,  $\gamma = 0.90$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Primary 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  $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness,  $t = 1.00$

Tensile Strength,  $f_{fu} = 840.00$

Tensile Modulus,  $E_f = 82000.00$

Elongation,  $\epsilon_{fu} = 0.009$

Number of directions,  $N_{Dir} = 1$

Fiber orientations,  $b_i: 0.00^\circ$

Number of layers,  $N_L = 1$

Radius of rounding corners,  $R = 40.00$

## Stepwise Properties

Bending Moment,  $M = -5.8822499E-011$

Shear Force,  $V_2 = 3112.69$

Shear Force,  $V_3 = 2.2719624E-013$

Axial Force,  $F = -15947.314$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 1137.257$

-Compression:  $As_{l,com} = 1137.257$

-Middle:  $As_{l,mid} = 402.1239$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{l,ten,jacket} = 829.3805$

-Compression:  $As_{l,com,jacket} = 829.3805$

-Middle:  $As_{l,mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{l,ten,core} = 307.8761$

-Compression:  $As_{l,com,core} = 307.8761$

-Middle:  $As_{l,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$



New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^* u = 0.0274056$   
 $u = y + p = 0.0274056$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00203441$  ((4.29), Biskinis Phd))  
 $M_y = 1.3183E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 3.2399E+013$   
 $factor = 0.30$   
 $A_g = 300000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 15947.314$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 1.0800E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \min(y_{ten}, y_{com})$   
 $y_{ten} = 5.6388532E-006$   
with ((10.1), ASCE 41-17)  $f_y = \min(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$   
 $d = 357.00$   
 $y = 0.22702375$   
 $A = 0.01018816$   
 $B = 0.00579182$   
with  $p_t = 0.00424746$   
 $p_c = 0.00424746$   
 $p_v = 0.00150186$   
 $N = 15947.314$   
 $b = 750.00$   
 $" = 0.12044818$   
 $y_{comp} = 2.7794074E-005$   
with  $f_c' (12.3, (ACI 440)) = 33.35499$   
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 750.00$   
 $h = 400.00$   
 $A_g = 300000.00$   
From (12.9), ACI 440:  $k_a = 0.14671972$   
 $g = p_t + p_c + p_v = 0.00999678$   
 $r_c = 40.00$   
 $A_e / A_c = 0.51581153$   
Effective FRP thickness,  $t_f = N L * t * \cos(b_1) = 1.00$   
effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.22410833$   
 $A = 0.00986286$   
 $B = 0.00560044$   
with  $E_s = 200000.00$

Calculation of ratio  $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.02537119$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$

shear control ratio  $V_{yE}/V_{CoIE} = 0.14265244$

$d = d_{\text{external}} = 357.00$

$s = s_{\text{external}} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00393687$

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  $2 \cdot t_f/bw \cdot (f_{fe}/f_s)$  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.

$NUD = 15947.314$

$A_g = 300000.00$

$f_{cE} = (f_{c\_jacket} \cdot \text{Area\_jacket} + f_{c\_core} \cdot \text{Area\_core}) / \text{section\_area} = 33.00$

$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot \text{Area\_ext\_Long\_Reinf} + f_{y\_int\_Long\_Reinf} \cdot \text{Area\_int\_Long\_Reinf}) / \text{Area\_Tot\_Long\_Rein} = 555.56$

$f_{yIE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$

$\rho_l = \text{Area\_Tot\_Long\_Rein} / (b \cdot d) = 0.00999678$

$b = 750.00$

$d = 357.00$

$f_{cE} = 33.00$

-----  
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

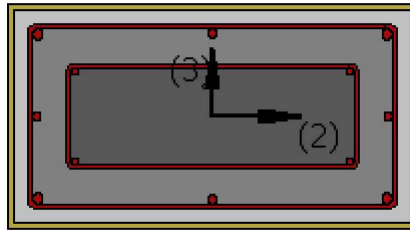
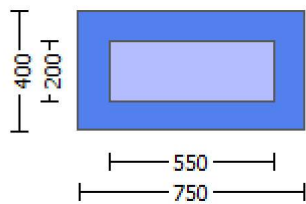
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1  
 At local axis: 3  
 Integration Section: (b)  
 Section Type: rcjrs

Constant Properties

---

Knowledge Factor,  $\gamma = 0.90$   
 Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
 Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of  $\gamma$  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  
 New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
 #####  
 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,  $L = 3000.00$   
 Primary 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  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 FRP Wrapping Data  
 Type: Carbon  
 Dry properties (design values)  
 Thickness,  $t = 1.00$   
 Tensile Strength,  $f_{fu} = 840.00$   
 Tensile Modulus,  $E_f = 82000.00$   
 Elongation,  $ε_{fu} = 0.009$   
 Number of directions,  $NoDir = 1$

Fiber orientations, bi: 0.00°  
Number of layers, NL = 1  
Radius of rounding corners, R = 40.00

#### Stepwise Properties

EDGE -A-  
Bending Moment, Ma = 7.4177612E-010  
Shear Force, Va = -2.2719624E-013  
EDGE -B-  
Bending Moment, Mb = -5.8822499E-011  
Shear Force, Vb = 2.2719624E-013  
BOTH EDGES  
Axial Force, F = -15947.314  
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

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR = 1.0\*Vn = 776982.499  
Vn ((10.3), ASCE 41-17) = knl\*VCol0 = 776982.499  
VCol = 776982.499  
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 = 25.00, but fc'^0.5 <= 8.3  
MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 5.8822499E-011  
Vu = 2.2719624E-013  
d = 0.8\*h = 320.00  
Nu = 15947.314  
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 = 500.00  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 234192.00  
f = 0.95, for fully-wrapped sections  
wf/sf = 1 (FRP strips adjacent to one another).  
In (11.3) sin + cos is replaced with (cot + cota)sina which is more a generalised expression,  
where is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,

as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$ , with:  
total thickness per orientation,  $t_{f1} = N_L * t / N_{\text{Dir}} = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 357.00  
 $f_{fe} ((11-5), \text{ACI } 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
with  $f_u = 0.009$   
From (11-11), ACI 440:  $V_s + V_f \leq 797164.595$   
 $b_w = 750.00$

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  $\theta = 3.7334643E-021$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00203441$  ((4.29), Biskinis Phd))  
 $M_y = 1.3183E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} * E_c * I_g = 3.2399E+013$   
factor = 0.30  
 $A_g = 300000.00$   
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$   
 $N = 15947.314$   
 $E_c * I_g = E_{c,\text{jacket}} * I_{g,\text{jacket}} + E_{c,\text{core}} * I_{g,\text{core}} = 1.0800E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 5.6388532E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$   
 $d = 357.00$   
 $y = 0.22702375$   
 $A = 0.01018816$   
 $B = 0.00579182$   
with  $p_t = 0.00424746$   
 $p_c = 0.00424746$   
 $p_v = 0.00150186$   
 $N = 15947.314$   
 $b = 750.00$   
 $\alpha = 0.12044818$   
 $y_{\text{comp}} = 2.7794074E-005$   
with  $f_c^*$  (12.3, (ACI 440)) = 33.35499  
 $f_c = 33.00$   
 $f_l = 0.77176471$   
 $b = 750.00$   
 $h = 400.00$   
 $A_g = 300000.00$   
From (12.9), ACI 440:  $k_a = 0.14671972$   
 $g = p_t + p_c + p_v = 0.00999678$   
 $r_c = 40.00$   
 $A_e / A_c = 0.51581153$   
Effective FRP thickness,  $t_f = N_L * t * \text{Cos}(\theta_1) = 1.00$   
effective strain from (12.5) and (12.12),  $\epsilon_{fe} = 0.004$   
 $f_u = 0.009$   
 $E_f = 82000.00$   
 $E_c = 26999.444$   
 $y = 0.22410833$   
 $A = 0.00986286$

B = 0.00560044  
with Es = 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: (b)

## Calculation No. 16

column C1, Floor 1

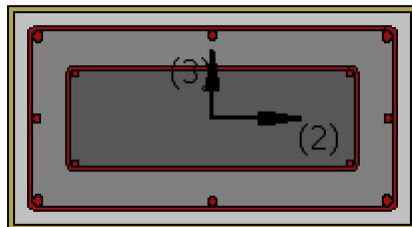
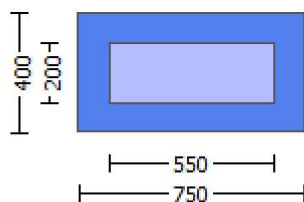
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( u)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

```

Existing Column
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
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 = 1.0435
Element Length,  $L = 3000.00$ 
Primary 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  $l_o/l_{ou,min} = 0.30$ 
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness,  $t = 1.00$ 
Tensile Strength,  $f_{fu} = 840.00$ 
Tensile Modulus,  $E_f = 82000.00$ 
Elongation,  $\epsilon_{fu} = 0.009$ 
Number of directions,  $NoDir = 1$ 
Fiber orientations,  $b_i: 0.00^\circ$ 
Number of layers,  $NL = 1$ 
Radius of rounding corners,  $R = 40.00$ 
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = 3.4586346E-031$ 
EDGE -B-
Shear Force,  $V_b = -3.4586346E-031$ 
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 ,  $V_e/V_r = 0.14265244$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 121055.918$ 
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.8158E+008$ 
 $M_{u1+} = 1.8158E+008$ , 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
 $M_{u1-} = 1.8158E+008$ , 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

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.8158\text{E}+008$$

$M_{u2+} = 1.8158\text{E}+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 1.8158\text{E}+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 1.7255512\text{E}-005$$

$$M_u = 1.8158\text{E}+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$\phi_{co} (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01006403$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.01006403$$

$$\phi_{we} ((5.4c), \text{TB DY}) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.02692906$$

where  $\phi_f = a_f * \phi_f^* * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00266667$$

$$b_w = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\phi_{fy} = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.005$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f,f} = 0.015$$

$$a_{se} ((5.4d), \text{TB DY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834\text{E}+006$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$\phi_{psh, \min} * f_{ywe} = \text{Min}(\phi_{psh, x} * f_{ywe}, \phi_{psh, y} * f_{ywe}) = 1.64062$$

Expression ((5.4d), TB DY) 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)

$$\phi_{psh, x} * f_{ywe} = \phi_{psh1} * f_{ywe1} + \phi_{ps2} * f_{ywe2} = 1.64062$$

$$\phi_{ps1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$



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 = 3.23907  
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 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00243499  
c = confinement factor = 1.0435

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
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 = 389.0139

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
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 = 389.0139

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  $fsv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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  $Esv = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.0500703$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.0500703$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc$  (5A.2, TBDY) = 34.43547  
 $cc$  (5A.5, TBDY) = 0.00243499  
 $c$  = confinement factor = 1.0435  
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.05941729$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05941729$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

---->  
 $v < vsy2$  - LHS eq.(4.5) is satisfied

---->  
 $su$  (4.9) = 0.16886055  
 $Mu = MRc$  (4.14) = 1.8158E+008  
 $u = su$  (4.1) = 1.7255512E-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:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = shear\_factor \cdot Max(cu, cc) = 0.01006403$

The  $Shear\_factor$  is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.01006403$

where ((5.4c), TBDY) =  $ase \cdot sh\_min \cdot fywe / fce + Min(fx, fy) = 0.02692906$

where  $f = af \cdot pf \cdot ffe / fce$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$fx = 0.02504965$   
 $af = 0.38744444$

$b = 750.00$   
 $h = 400.00$

From EC8 A4.4.3(6),  $pf = 2tf/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $ffe = 800.0873$

$fy = 0.04491794$

$af = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A4.4.3(6),  $pf = 2tf/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $ff,e = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $tf = NL*t*Cos(b1) = 1.00$   
 $fu,f = 840.00$   
 $Ef = 82000.00$   
 $u,f = 0.015$   
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = Max(ase1,ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$

$psh,min*Fywe = Min(psh,x*Fywe, psh,y*Fywe) = 1.64062$   
 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)

$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.64062$   
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.0020944$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.23907$   
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 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,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c =$  confinement factor = 1.0435

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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 fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with 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) = 0.0500703
2 = Asl,com/(b*d)*(fs2/fc) = 0.0500703
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05941729
2 = Asl,com/(b*d)*(fs2/fc) = 0.05941729
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) = 0.16886055
Mu = MRc (4.14) = 1.8158E+008
u = su (4.1) = 1.7255512E-005

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu2+

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7255512E-005$$

$$Mu = 1.8158E+008$$

with full section properties:

$$b = 750.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00124684$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$\alpha (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01006403$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01006403$$

$$\phi_{we} ((5.4c), TBDY) = \alpha \cdot \phi_u \cdot \min(f_{ywe}/f_{ce} + \min(f_x, f_y)) = 0.02692906$$

where  $f = \alpha \cdot \phi_u \cdot f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.02504965$$

$$\alpha_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$f_y = 0.04491794$$

$$\alpha_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL \cdot t \cdot \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$u_{f,f} = 0.015$$

$$\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.12601038$$

$$\alpha_{se1} = 0.12601038$$

$$b_{o\_1} = 690.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 1.1834E+006$$

$$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$$

$$b_{o\_2} = 542.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 661256.00$$

$$\phi_{sh, \min} \cdot F_{ywe} = \text{Min}(\phi_{sh, x} \cdot F_{ywe}, \phi_{sh, y} \cdot F_{ywe}) = 1.64062$$

Expression ((5.4d), TBDY) for  $\phi_{sh, \min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{sh, x} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 1.64062$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00026808$$

$$A_{sh2} = A_{stir\_2} \cdot n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$\phi_{sh, y} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.23907$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} \cdot n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $No \text{ stirups, } ns\_2 = 2.00$   
 $h2 = 550.00$

$Asec = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$

$ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.30$

$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 389.0139$

with  $Es1 = (Es\_jacket \cdot Asl, ten, jacket + Es\_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$

$ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 0.30$

$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 389.0139$

with  $Es2 = (Es\_jacket \cdot Asl, com, jacket + Es\_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.00140044$   
 $shv = 0.0044814$

$ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.30$

$suv = 0.4 \cdot esuv\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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  $Es_v = (Es\_jacket \cdot Asl, mid, jacket + Es\_mid \cdot Asl, mid, core) / Asl, mid = 200000.00$

$1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.0500703$

$2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.0500703$

$v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05941729$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05941729$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02100943$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.16886055$   
 $Mu = MRc (4.14) = 1.8158E+008$   
 $u = su (4.1) = 1.7255512E-005$

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  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7255512E-005$   
 $Mu = 1.8158E+008$

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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01006403$   
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $a_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $a_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$

$u, f = 0.015$   
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.12601038$   
 $ase1 = 0.12601038$   
 $bo\_1 = 690.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 1.1834E+006$   
 $ase2 = \text{Max}(ase1, ase2) = 0.12601038$   
 $bo\_2 = 542.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 661256.00$   
 $psh, \min \cdot F_{ywe} = \text{Min}(psh, x \cdot F_{ywe}, psh, y \cdot F_{ywe}) = 1.64062$   
 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)

$psh, x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 1.64062$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.0020944$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00026808$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$psh, y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.23907$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirrups,  $ns\_1 = 2.00$   
 $h1 = 750.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00073723$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirrups,  $ns\_2 = 2.00$   
 $h2 = 550.00$

$A_{sec} = 300000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A5), TBDY), TBDY:  $cc = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lo, \min = lb/ld = 0.30$   
 $su1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs, \text{jacket} \cdot A_{sl, \text{ten, jacket}} + fs, \text{core} \cdot A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 389.0139$   
 with  $Es1 = (Es, \text{jacket} \cdot A_{sl, \text{ten, jacket}} + Es, \text{core} \cdot A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lo, \min = lb/lb, \min = 0.30$



$su_2 = 0.4 \cdot esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 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.  
 with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 389.0139$   
 with  $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 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  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fs_v/1.2$ , 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  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 389.0139$   
 with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.0500703$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.0500703$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.01770442$

and confined core properties:

$b = 690.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.05941729$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05941729$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.02100943$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.16886055$

$\mu_u = MR_c (4.14) = 1.8158E+008$

$u = su (4.1) = 1.7255512E-005$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 848607.437$

Calculation of Shear Strength at edge 1,  $V_{r1} = 848607.437$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$

$V_{Col0} = 848607.437$

$knl = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot fy \cdot d/s$ ' is replaced by ' $V_s + f^*V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$   
 $\mu_u = 3.5345895E-012$   
 $\mu_v = 3.4586346E-031$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
 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  $\text{Col1} = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $\text{Col2} = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 234192.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $w_f/s_f = 1$  (FRP strips adjacent to one another).  
 In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a) \sin a$  which is more a generalised expression,  
 where  $a$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(\theta, a)$ , is implemented for every different fiber orientation  $a_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta = b1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$   
 $d_{fv} = d$  (figure 11.2, ACI 440) = 357.00  
 $f_{fe} ((11-5), \text{ACI 440}) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $b_w = 750.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 848607.437$   
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{\text{ColO}}$   
 $V_{\text{ColO}} = 848607.437$   
 $k_n l = 1$  (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).

$\lambda = 1$  (normal-weight concrete)  
 Mean concrete strength:  $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$   
 $\mu_u = 3.5345895E-012$   
 $\mu_v = 3.4586346E-031$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
 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  $\text{Col1} = 1.00$   
 $s/d = 0.3125$

$V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f((11-3)-(11.4), ACI 440) = 234192.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $wf/sf = 1$  (FRP strips adjacent to one another).  
 In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
 where  $a$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta_1 = b1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a1)|)$ , with:  
 total thickness per orientation,  $tf1 = NL * t / NoDir = 1.00$   
 $dfv = d$  (figure 11.2, ACI 440) = 357.00  
 $ffe((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
 with  $f_u = 0.009$   
 From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 750.00$

-----  
 -----  
 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,  $\phi = 0.90$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Jacket  
 New material: Steel Strength,  $f_s = 1.25 * f_{sm} = 694.45$   
 Existing Column  
 New material: Steel Strength,  $f_s = 1.25 * f_{sm} = 694.45$   
 #####  
 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 = 1.0435  
 Element Length,  $L = 3000.00$

Primary 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  $l_o/l_{o,min} = 0.30$   
FRP Wrapping Data  
Type: Carbon  
Dry properties (design values)  
Thickness,  $t = 1.00$   
Tensile Strength,  $f_{fu} = 840.00$   
Tensile Modulus,  $E_f = 82000.00$   
Elongation,  $\epsilon_{fu} = 0.009$   
Number of directions,  $NoDir = 1$   
Fiber orientations,  $b_i = 0.00^\circ$   
Number of layers,  $NL = 1$   
Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 2.9582284E-031$   
EDGE -B-  
Shear Force,  $V_b = -2.9582284E-031$   
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:  $As_{l,com} = 1137.257$   
-Middle:  $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.19671905$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 248405.514$   
with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.7261E+008$   
 $\mu_{u1+} = 3.7261E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 3.7261E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.7261E+008$   
 $\mu_{u2+} = 3.7261E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 3.7261E+008$ , 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 $\mu_{u1+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu = 8.5888248E-006$   
 $M_u = 3.7261E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$

$v = 0.00118049$   
 $N = 11016.808$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
 Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01006403$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\alpha = 0.01006403$   
 $\alpha_e ((5.4c), TBDY) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$   
 where  $f = \alpha * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$   
 $\alpha_f = 0.38744444$   
 $b = 750.00$   
 $h = 400.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$   
 $bw = 750.00$   
 effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$   
 $\alpha_f = 0.38744444$   
 $b = 400.00$   
 $h = 750.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.005$   
 $bw = 400.00$   
 effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.00$   
 $f_{u,f} = 840.00$   
 $E_f = 82000.00$   
 $u_{f,f} = 0.015$   
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.12601038$   
 $\alpha_{se1} = 0.12601038$   
 $b_{o\_1} = 690.00$   
 $h_{o\_1} = 340.00$   
 $b_{i2\_1} = 1.1834E+006$   
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$   
 $b_{o\_2} = 542.00$   
 $h_{o\_2} = 192.00$   
 $b_{i2\_2} = 661256.00$   
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 1.64062$

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)

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 1.64062$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 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,  $n_{s\_2} = 2.00$   
 $h_2 = 200.00$

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.23907$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 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,  $n_{s\_2} = 2.00$   
 $h_2 = 550.00$

$A_{sec} = 300000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$

```

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5A.5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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 = 389.0139
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) = 0.04740567
2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
c = confinement factor = 1.0435
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
v = Asl,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

--->

$s_u$  (4.9) = 0.15682678

$\mu_u = M_{Rc}$  (4.14) = 3.7261E+008

$u = s_u$  (4.1) = 8.5888248E-006

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u1}$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.5888248E-006$

$\mu_u = 3.7261E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00118049$

$N = 11016.808$

$f_c = 33.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\alpha_u$ :  $\alpha_u^* = \text{shear\_factor} * \text{Max}(\alpha_u, \alpha_c) = 0.01006403$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\alpha_u = 0.01006403$

$w_e$  ((5.4c), TBDY) =  $\alpha_{se} * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.02692906$

where  $f = \alpha_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.02504965$

$\alpha_f = 0.38744444$

$b = 750.00$

$h = 400.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00266667$

$bw = 750.00$

effective stress from (A.35),  $f_{fe} = 800.0873$

$f_y = 0.04491794$

$\alpha_f = 0.38744444$

$b = 400.00$

$h = 750.00$

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.005$

$bw = 400.00$

effective stress from (A.35),  $f_{fe} = 765.1636$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.00$

$f_{u,f} = 840.00$

$E_f = 82000.00$

$u_{f,f} = 0.015$

$\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.12601038$

$\alpha_{se1} = 0.12601038$

$bo\_1 = 690.00$

$ho\_1 = 340.00$

$bi2\_1 = 1.1834E+006$

$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.12601038$

$bo\_2 = 542.00$

$ho\_2 = 192.00$

```

bi2_2 = 661256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.64062
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 = 1.64062
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 = 3.23907
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 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: cc = 0.00243499
c = confinement factor = 1.0435
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
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 Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 389.0139
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
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/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 389.0139
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,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) = 0.04740567
    2 = Asl,com/(b*d)*(fs2/fc) = 0.04740567
    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) = 34.43547
cc (5A.5, TBDY) = 0.00243499
    c = confinement factor = 1.0435
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05824278
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05824278
    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) = 0.15682678
Mu = MRc (4.14) = 3.7261E+008
u = su (4.1) = 8.5888248E-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 = 8.5888248E-006

Mu = 3.7261E+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) = 0.01006403

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01006403

we ((5.4c), TBDY) = ase\* sh,min\*fywe/fce+Min( fx, fy) = 0.02692906

where f = af\*pf\*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

fx = 0.02504965

af = 0.38744444  
b = 750.00  
h = 400.00  
From EC8 A4.4.3(6), pf =  $2t_f/bw = 0.00266667$   
bw = 750.00  
effective stress from (A.35), ff,e = 800.0873

fy = 0.04491794  
af = 0.38744444  
b = 400.00  
h = 750.00  
From EC8 A4.4.3(6), pf =  $2t_f/bw = 0.005$   
bw = 400.00  
effective stress from (A.35), ff,e = 765.1636

R = 40.00  
Effective FRP thickness, tf =  $NL \cdot t \cdot \cos(b1) = 1.00$   
fu,f = 840.00  
Ef = 82000.00  
u,f = 0.015  
ase ((5.4d), TBDY) =  $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.12601038$   
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\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 1.64062  
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 = 1.64062  
ps1 (external) =  $(Ash1 \cdot h1/s1) / A_{sec} = 0.0020944$   
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) =  $(Ash2 \cdot h2/s2) / A_{sec} = 0.00026808$   
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirrups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.23907  
ps1 (external) =  $(Ash1 \cdot h1/s1) / A_{sec} = 0.00392699$   
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirrups, ns\_1 = 2.00  
h1 = 750.00  
ps2 (internal) =  $(Ash2 \cdot h2/s2) / A_{sec} = 0.00073723$   
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 = 694.45  
fce = 33.00  
From ((5.A5), TBDY), TBDY: cc = 0.00243499  
c = confinement factor = 1.0435  
y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,  
For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 389.0139$   
with  $Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 389.0139$   
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  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 389.0139$   
with  $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.04740567$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04740567$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01676222$   
and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.43547$   
 $cc (5A.5, TBDY) = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05824278$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05824278$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02059413$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
--->  
 $su (4.9) = 0.15682678$   
 $Mu = MRc (4.14) = 3.7261E+008$   
 $u = su (4.1) = 8.5888248E-006$

-----  
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:

$$\mu = 8.5888248 \times 10^{-6}$$

$$\mu_2 = 3.7261 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00118049$$

$$N = 11016.808$$

$$f_c = 33.00$$

$$\mu_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_2: \mu_2 = \text{shear\_factor} * \text{Max}(\mu_0, \mu_0) = 0.01006403$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_2 = 0.01006403$$

$$\mu_2 \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_{fx}, \mu_{fy}) = 0.02692906$$

where  $\mu_f = a_f * \mu_{pf} * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_{fx} = 0.02504965$$

$$a_f = 0.38744444$$

$$b = 750.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.00266667$$

$$bw = 750.00$$

$$\text{effective stress from (A.35), } f_{fe} = 800.0873$$

$$\mu_{fy} = 0.04491794$$

$$a_f = 0.38744444$$

$$b = 400.00$$

$$h = 750.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.005$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 765.1636$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.00$$

$$f_{u,f} = 840.00$$

$$E_f = 82000.00$$

$$\mu_{u,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.12601038$$

$$a_{se1} = 0.12601038$$

$$b_{o,1} = 690.00$$

$$h_{o,1} = 340.00$$

$$b_{i2,1} = 1.1834 \times 10^{-6}$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.12601038$$

$$b_{o,2} = 542.00$$

$$h_{o,2} = 192.00$$

$$b_{i2,2} = 661256.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 1.64062$$

Expression ((5.4d), TBDY) for  $\mu_{sh,min} * f_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 1.64062$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.0020944$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00026808$$

Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.23907  
 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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00243499

c = confinement factor = 1.0435

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

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 = 389.0139

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

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 = 389.0139

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  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 389.0139$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.04740567$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.04740567$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.01676222$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 34.43547$   
 $cc \text{ (5A.5, TBDY)} = 0.00243499$   
 $c = \text{confinement factor} = 1.0435$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.05824278$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.05824278$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.02059413$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su \text{ (4.9)} = 0.15682678$

$Mu = MR_c \text{ (4.14)} = 3.7261E+008$

$u = su \text{ (4.1)} = 8.5888248E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.2627E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.2627E+006$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$

$V_{Col0} = 1.2627E+006$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} + f \cdot V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot A_{jacket} + f'_{c,core} \cdot A_{core}) / A_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 2.3795529E-012$

$Vu = 2.9582284E-031$

$d = 0.8 \cdot h = 600.00$

$Nu = 11016.808$

$Ag = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$

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  $Col1 = 1.00$

$s/d = 0.16666667$

$V_{s2} = 98297.73$  is calculated for core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 463792.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $wf/sf = 1$  (FRP strips adjacent to one another).  
In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
where  $a$  is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function  $V_f(, )$ , is implemented for every different fiber orientation  $a_i$ ,  
as well as for 2 crack directions,  $= 45^\circ$  and  $= -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $\theta = b1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:  
total thickness per orientation,  $tf1 = NL * t / NoDir = 1.00$   
 $dfv = d$  (figure 11.2, ACI 440) = 707.00  
 $ffe ((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$   
 $f_e = 0.004$ , from (11.6a), ACI 440  
with  $f_u = 0.009$   
From (11-11), ACI 440:  $V_s + V_f \leq 915872.391$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.2627E+006$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$   
 $V_{Col0} = 1.2627E+006$   
 $knl = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.3795529E-012$   
 $V_u = 2.9582284E-031$   
 $d = 0.8 * h = 600.00$   
 $N_u = 11016.808$   
 $A_g = 300000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 621900.694$   
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  $Col1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s2} = 98297.73$  is calculated for core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 463792.00$   
 $f = 0.95$ , for fully-wrapped sections  
 $wf/sf = 1$  (FRP strips adjacent to one another).  
In (11.3)  $\sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
where  $a$  is the angle of the crack direction (see KANEPE).  
This later relation, considered as a function  $V_f(, )$ , is implemented for every different fiber orientation  $a_i$ ,  
as well as for 2 crack directions,  $= 45^\circ$  and  $= -45^\circ$  to take into consideration the cyclic seismic loading.  
orientation 1:  $\theta = b1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$ , with:  
total thickness per orientation,  $tf1 = NL * t / NoDir = 1.00$   
 $dfv = d$  (figure 11.2, ACI 440) = 707.00  
 $ffe ((11-5), ACI 440) = 328.00$   
 $E_f = 82000.00$

fe = 0.004, from (11.6a), ACI 440  
with fu = 0.009  
From (11-11), ACI 440: Vs + Vf <= 915872.391  
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (b)  
Section Type: rcjrs

#### Constant Properties

Knowledge Factor,  $\gamma = 0.90$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
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,  $L = 3000.00$   
Primary 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  $l_b/l_d = 0.30$   
FRP Wrapping Data  
Type: Carbon  
Dry properties (design values)  
Thickness,  $t = 1.00$   
Tensile Strength,  $f_{fu} = 840.00$   
Tensile Modulus,  $E_f = 82000.00$   
Elongation,  $\epsilon_{fu} = 0.009$   
Number of directions,  $N_{oDir} = 1$   
Fiber orientations,  $b_i: 0.00^\circ$   
Number of layers,  $N_L = 1$   
Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

Bending Moment,  $M = 1.6361E+006$   
Shear Force,  $V_2 = 3112.69$   
Shear Force,  $V_3 = 2.2719624E-013$   
Axial Force,  $F = -15947.314$   
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,  $DbL = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.0304039$

$u = y + p = 0.0304039$

- Calculation of  $y$  -

$y = (My * Ls / 3) / E_{eff} = 0.0004039$  ((4.29), Biskinis Phd))

$My = 2.6257E+008$

$Ls = M/V$  (with  $Ls > 0.1 * L$  and  $Ls < 2 * L$ ) = 525.6338

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.1390E+014$

$factor = 0.30$

$Ag = 300000.00$

Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 15947.314$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.7968E+014$

Calculation of Yielding Moment  $My$

Calculation of  $y$  and  $My$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 2.8044129E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$

$d = 707.00$

$y = 0.21519134$

$A = 0.00964597$

$B = 0.00520141$

with  $pt = 0.00402142$

$pc = 0.00402142$

$pv = 0.00142194$

$N = 15947.314$

$b = 400.00$

$" = 0.06082037$

$y_{comp} = 1.4823586E-005$

with  $fc^*$  (12.3, (ACI 440)) = 33.35516

$fc = 33.00$

$fl = 0.77176471$

$b = 400.00$

$h = 750.00$

$Ag = 300000.00$

From (12.9), ACI 440:  $ka = 0.14679369$

$g = pt + pc + pv = 0.00946477$

$rc = 40.00$

$A_e / A_c = 0.51607158$

Effective FRP thickness,  $tf = NL * t * \cos(b1) = 1.00$

effective strain from (12.5) and (12.12),  $efe = 0.004$

$fu = 0.009$

$Ef = 82000.00$

$E_c = 26999.444$   
 $y = 0.21218177$   
 $A = 0.00933798$   
 $B = 0.00502021$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$

shear control ratio  $V_y E / V_{Col} E = 0.19671905$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00761619$

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  $2 * t_f / b_w * (f_{fe} / f_s)$  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.

$N_{UD} = 15947.314$

$A_g = 300000.00$

$f_{cE} = (f_{c\_jacket} * Area\_jacket + f_{c\_core} * Area\_core) / section\_area = 33.00$

$f_{yE} = (f_{y\_ext\_Long\_Reinf} * Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} * Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein =$

$555.56$

$f_{yE} = (f_{y\_ext\_Trans\_Reinf} * s_1 + f_{y\_int\_Trans\_Reinf} * s_2) / (s_1 + s_2) = 555.56$

$p_l = Area\_Tot\_Long\_Rein / (b * d) = 0.00946477$

$b = 400.00$

$d = 707.00$

$f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)