

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

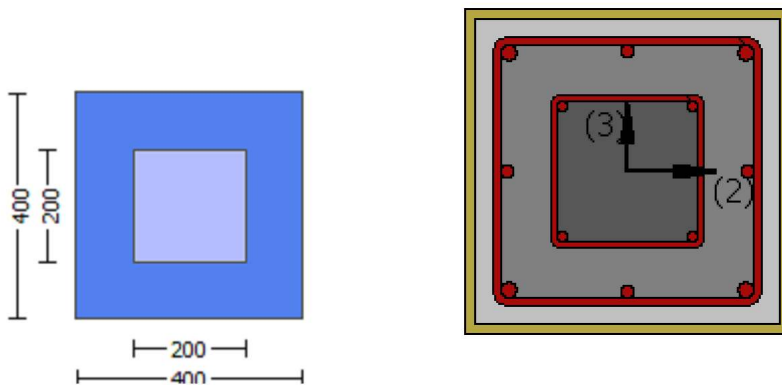
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.80$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of γ for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, $f_c = f_{cm} = 33.00$
New material: Steel Strength, $f_s = f_{sm} = 555.56$
Existing Column
New material: Concrete Strength, $f_c = f_{cm} = 33.00$
New material: Steel Strength, $f_s = f_{sm} = 555.56$

External Height, $H = 400.00$
External Width, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $ef_u = 0.01$
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, $M_a = -1.7258E+007$
Shear Force, $V_a = -5750.847$
EDGE -B-
Bending Moment, $M_b = 0.00815737$
Shear Force, $V_b = 5750.847$
BOTH EDGES
Axial Force, $F = -5974.507$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1137.257$
-Compression: $As_c = 1539.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{l,com} = 1137.257$
-Middle: $As_{l,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 505466.139$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{CoIO} = 505466.139$

VCol = 505466.139
knl = 1.00
displacement_ductility_demand = 0.02169271

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)
 $M/Vd = 4.00$
 $\mu_u = 1.7258E+007$
 $V_u = 5750.847$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5974.507$
 $A_g = 160000.00$
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) = 188111.148
 $f = 0.95$, 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, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 425154.451$
 $b_w = 400.00$

displacement_ductility_demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 0.00028349$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01306853$ ((4.29), Biskinis Phd))
 $M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.88
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.7280E+013$
factor = 0.30
 $A_g = 160000.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 33.00$
 $N = 5974.507$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.0810812\text{E-}005$
with $f_y = 555.56$
 $d = 357.00$
 $y = 0.280262$
 $A = 0.01881926$
 $B = 0.01057612$
with $p_t = 0.00796398$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.507$
 $b = 400.00$
 $" = 0.12044818$
 $y_{\text{comp}} = 2.3130541\text{E-}005$
with $f_c^* (12.3, (ACI 440)) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e/A_c = 0.56518315$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975145$
 $A = 0.0186534$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

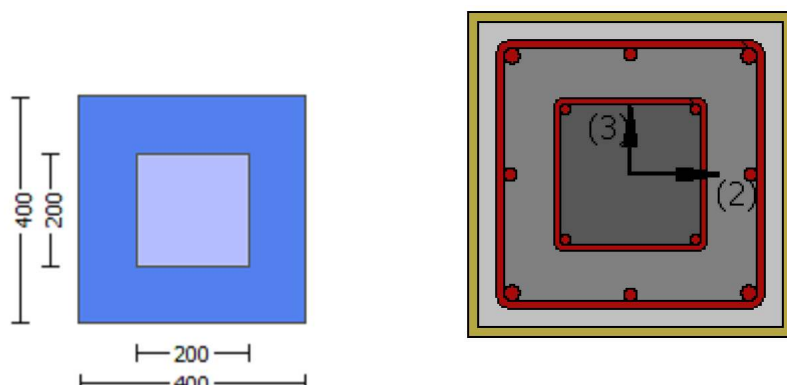
End Of Calculation of Shear Capacity for element: column JC1 of floor 1

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 (ϕ)
 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, $\gamma = 0.80$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

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Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.13212

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

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, $V_a = 5.2204734E-032$

EDGE -B-

Shear Force, $V_b = -5.2204734E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

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, $V_e/V_r = 0.35962554$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.4650E+008$

$\mu_{u1+} = 3.4650E+008$, 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

$\mu_{u1-} = 3.4650E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.4650E+008$

$\mu_{u2+} = 3.4650E+008$, 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

$\mu_{u2-} = 3.4650E+008$, 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 μ_{u1+}

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

$\phi_u = 0.00010712$

$\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

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

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01506636$

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

From (5.4b), TBDY: $cu = 0.01506636$

we ((5.4c), TBDY) = $ase * sh_{min} * fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.08361288$

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

$fx = 0.07683125$

$af = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$fy = 0.07683125$

$af = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$

Effective FRP thickness, $tf = NL * t * \text{Cos}(b1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$

$ase1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$psh_{min} * fy_{we} = \text{Min}(psh_x * fy_{we}, psh_y * fy_{we}) = 3.07617$

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

$psh_x * fy_{we} = psh1 * fy_{we1} + ps2 * fy_{we2} = 3.07617$

$ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00050265$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$psh_y * fy_{we} = psh1 * fy_{we1} + ps2 * fy_{we2} = 3.07617$

$ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00392699$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00050265$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$A_{sec} = 160000.00$

$s1 = 100.00$

$s2 = 250.00$

$fy_{we1} = 694.45$

$fy_{we2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

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c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

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$$su(4.9) = 0.16321971$$

$$Mu = MRc(4.14) = 3.4650E+008$$

$$u = su(4.1) = 0.00010712$$

Calculation of ratio lb/ld

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

Calculation of $Mu1$ -

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

$$u = 0.00010712$$

$$Mu = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01506636$$

$$we((5.4c), TBDY) = ase * sh, \min * fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.08361288$$

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

$$fx = 0.07683125$$

$$af = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2tf/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } ff,e = 870.5244$$

$$fy = 0.07683125$$

$$af = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2tf/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } ff,e = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } tf = NL * t * \cos(b1) = 1.016$$

$$fu,f = 1055.00$$

$$Ef = 64828.00$$

$$u,f = 0.015$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$$

$$ase1 = 0.24250288$$

$$bo_1 = 340.00$$

$$ho_1 = 340.00$$

$$bi2_1 = 462400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.24250288$$

$$bo_2 = 192.00$$

$$ho_2 = 192.00$$

$$bi2_2 = 147456.00$$

$$psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 3.07617$$

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)

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00332119$

$c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

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

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

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

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

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

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

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

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

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

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

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.34$

$fyv = 694.45$

$suv = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and 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 $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.21525776$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

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

Calculation of Mu_{2+}

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

$u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01506636$
 $we ((5.4c), TBDY) = ase * sh_{min} * fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.08361288$
 where $f = af * pf * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

 $fx = 0.07683125$
 $af = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$

bw = 400.00
effective stress from (A.35), $f_{f,e} = 870.5244$

fy = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
bw = 400.00
effective stress from (A.35), $f_{f,e} = 870.5244$

R = 40.00
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase \text{ ((5.4d), TBDY)} = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.24250288$
 $ase_1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi_2_1 = 462400.00$
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi_2_2 = 147456.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $lo/lo_{u,min} = lb/ld = 1.00$
 $su_1 = 0.4 \cdot esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs_jacket \cdot Asl_ten_jacket + fs_core \cdot Asl_ten_core) / Asl_ten = 694.45$
with $Es1 = (Es_jacket \cdot Asl_ten_jacket + Es_core \cdot Asl_ten_core) / Asl_ten = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu2_nominal = 0.08$,
For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs2 = (fs_jacket \cdot Asl_com_jacket + fs_core \cdot Asl_com_core) / Asl_com = 694.45$
with $Es2 = (Es_jacket \cdot Asl_com_jacket + Es_core \cdot Asl_com_core) / Asl_com = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (fs_jacket \cdot Asl_mid_jacket + fs_mid \cdot Asl_mid_core) / Asl_mid = 694.45$
with $Es_v = (Es_jacket \cdot Asl_mid_jacket + Es_mid \cdot Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.05925959$
and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.21525776$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.21525776$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.07611324$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

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

Calculation of Mu2-

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

$$\mu = 0.00010712$$

$$Mu = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$

$$w_e \text{ ((5.4c), TBDY)} = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

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

$$f_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

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

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

$$b_{i,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

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

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

$$b_{i,2} = 147456.00$$

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.07617$$

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)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00332119

c = confinement factor = 1.13212

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.16759354$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.16759354$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05925959$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 37.35991$$

$$c_c (5A.5, TBDY) = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.16321971$$

$$M_u = M_{Rc} (4.14) = 3.4650E+008$$

$$u = s_u (4.1) = 0.00010712$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

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

$$V_{Col0} = 642326.47$$

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

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

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

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

$$M/Vd = 2.00$$

$$M_u = 9.9249344E-012$$

$$V_u = 5.2204734E-032$$

$$d = 0.8 * h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

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

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 $Col2 = 0.00$

$$s/d = 1.5625$$

$$V_f ((11-3)-(11.4), ACI 440) = 188111.148$$

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

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 θ is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_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: $\theta = \theta_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

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

$f_{fe}((11-5), \text{ACI 440}) = 259.312$

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$

$V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{Col0}$

$V_{Col0} = 642326.47$

$k_n l = 1$ (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).

$\gamma_c = 1$ (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)

$M / V d = 2.00$

$\mu_u = 9.9249344 \text{E-}012$

$\nu_u = 5.2204734 \text{E-}032$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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 $\text{Col2} = 0.00$

$s/d = 1.5625$

$V_f((11-3)-(11.4), \text{ACI 440}) = 188111.148$

$f = 0.95$, 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 θ is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_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: $\theta = \theta_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

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

$f_{fe}((11-5), \text{ACI 440}) = 259.312$

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

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, $\gamma = 0.80$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.13212

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

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, $V_a = -4.7900285E-031$

EDGE -B-

Shear Force, $V_b = 4.7900285E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

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, $V_e/V_r = 0.35962554$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.4650E+008$

$Mu_{1+} = 3.4650E+008$, 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

$Mu_{1-} = 3.4650E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.4650E+008$

$Mu_{2+} = 3.4650E+008$, 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

$Mu_{2-} = 3.4650E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 0.00010712$

$M_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01506636$

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

From (5.4b), TBDY: $\phi_u = 0.01506636$

$\phi_{we} ((5.4c), TBDY) = a_s e^* \phi_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$

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

$\phi_{fx} = 0.07683125$

$a_s = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/b_w = 0.00508$

$b_w = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$\phi_{fy} = 0.07683125$

$a_s = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/b_w = 0.00508$

$b_w = 400.00$

effective stress from (A.35), $f_{f,e} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$ase((5.4d), TBDY) = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.24250288$

$ase_1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi_{2,1} = 462400.00$

$ase_2 = \max(ase_1, ase_2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi_{2,2} = 147456.00$

$psh_{,min} \cdot F_{ywe} = \min(psh_{,x} \cdot F_{ywe}, psh_{,y} \cdot F_{ywe}) = 3.07617$

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

$psh_{,x} \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 3.07617$

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

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2 \text{ (internal)} = (Ash_2 \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$Ash_2 = Astir_2 \cdot ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h_2 = 200.00$

$psh_{,y} \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + ps_2 \cdot F_{ywe2} = 3.07617$

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

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2 \text{ (internal)} = (Ash_2 \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$Ash_2 = Astir_2 \cdot ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

$c = \text{confinement factor} = 1.13212$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

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

$lo/lo_{u,min} = l_b/l_d = 1.00$

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

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 $fs_1 = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 694.45$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

```

fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/d = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
    c = confinement factor = 1.13212
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
    2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01506636$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.01506636$$

$$w_e ((5.4c), \text{TB DY}) = \alpha s_e * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

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

$$f_x = 0.07683125$$

$$\alpha f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$\alpha f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha s_e ((5.4d), \text{TB DY}) = (\alpha s_{e1} * A_{ext} + \alpha s_{e2} * A_{int}) / A_{sec} = 0.24250288$$

$$\alpha s_{e1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$\alpha s_{e2} = \text{Max}(\alpha s_{e1}, \alpha s_{e2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

Expression ((5.4d), TB DY) 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)

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

```

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A.5), TBDY), TBDY: cc = 0.00332119
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119

```

$c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

$\mu_u(4.9) = 0.16321971$
 $\mu_u = M_{Rc}(4.14) = 3.4650E+008$
 $u = \mu_u(4.1) = 0.00010712$

Calculation of ratio l_b/d

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

Calculation of μ_{u2+}

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

$u = 0.00010712$
 $\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha_{co}(5A.5, TBDY) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.01506636$
 $\mu_{we}((5.4c), TBDY) = \alpha_{se} * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = \alpha_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int})/A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o_1} = 340.00$
 $h_{o_1} = 340.00$

$bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.07617$
 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)

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

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

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

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

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

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

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

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

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

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

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636

```

$w_e ((5.4c), TBDY) = a_{se} \cdot \frac{sh_{min} \cdot f_{ywe}}{f_{ce}} + \min(f_x, f_y) = 0.08361288$
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)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f / b_w = 0.00508$
 $b_w = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f / b_w = 0.00508$
 $b_w = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
Effective FRP thickness, $t_f = N_L \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$
 $a_{se1} = 0.24250288$
 $b_{o,1} = 340.00$
 $h_{o,1} = 340.00$
 $b_{i2,1} = 462400.00$
 $a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$
 $b_{o,2} = 192.00$
 $h_{o,2} = 192.00$
 $b_{i2,2} = 147456.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $p_{s1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$
No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $p_{s2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$
No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $p_{s1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$
No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $p_{s2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$
No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$
From ((5.A5), TBDY), TBDY: $c_c = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $y_1 = 0.0025$
 $sh_1 = 0.008$

```

ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
    c = confinement factor = 1.13212
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
    2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008

```

$$u = s_u(4.1) = 0.00010712$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

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

$V_{Col0} = 642326.47$

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

$M/Vd = 2.00$

$\mu_u = 1.3318154E-012$

$\mu_v = 4.7900285E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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 $\text{Col2} = 0.00$

$s/d = 1.5625$

$V_f((11-3)-(11.4), \text{ACI } 440) = 188111.148$

$f = 0.95$, 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, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.016$

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

$f_{fe}((11-5), \text{ACI } 440) = 259.312$

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$

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

$V_{Col0} = 642326.47$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3318154E-012$

$\nu_u = 4.7900285E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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), ACI 440) = 188111.148

$f = 0.95$, for fully-wrapped sections

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

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot_a) \sin \alpha$ which is more a generalised expression, where α 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 α_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: $\alpha_1 = \alpha_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

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

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

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, $\phi = 0.80$

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

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/d \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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, $M = 2.1072102E-010$
 Shear Force, $V_2 = -5750.847$
 Shear Force, $V_3 = -1.0642330E-013$
 Axial Force, $F = -5974.507$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1137.257$
 -Compression: $As_c = 1539.38$
 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 $u_R = 1.0^*$ $u = 0.01153235$
 $u = y + p = 0.01153235$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00653235 ((4.29), \text{Biskinis Phd})$

$M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1*L$ and $L_s < 2*L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.507$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0810812E-005$
 with $f_y = 555.56$
 $d = 357.00$
 $y = 0.280262$
 $A = 0.01881926$
 $B = 0.01057612$
 with $p_t = 0.00680078$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.507$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.3130541E-005$
 with f_c^* (12.3, (ACI 440)) = 34.65043
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
 From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e/A_c = 0.56518315$
 Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.016$
 effective strain from (12.5) and (12.12), $e_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975145$
 $A = 0.0186534$
 $B = 0.01050082$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.005$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$
 shear control ratio $V_y E / V_{col} O E = 0.35962554$
 $d = d_{external} = 357.00$
 $s = s_{external} = 0.00$
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00680078$
 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
 $h_1 = 400.00$

$$s1 = 100.00$$

$$\text{core: } s2 = A_{v2} \cdot h^2 / (s2 \cdot A_g) = 0.00050265$$

$A_{v2} = 100.531$, 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.

$$N_{UD} = 5974.507$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c_jacket} \cdot A_{jacket} + f_{c_core} \cdot A_{core}) / \text{section_area} = 33.00$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot A_{ext_Long_Reinf} + f_{y_int_Long_Reinf} \cdot A_{int_Long_Reinf}) / A_{Tot_Long_Rein} = 555.56$$

$$f_{yTE} = (f_{y_ext_Trans_Reinf} \cdot A_{ext_Trans_Reinf} + f_{y_int_Trans_Reinf} \cdot A_{int_Trans_Reinf}) / A_{Tot_Trans_Rein} = 555.56$$

$$\rho_l = A_{Tot_Long_Rein} / (b \cdot d) = 0.01874396$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

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

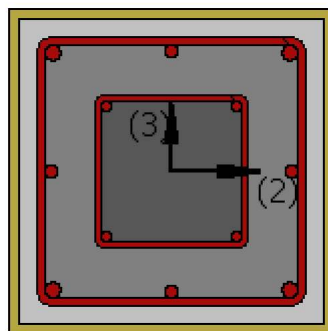
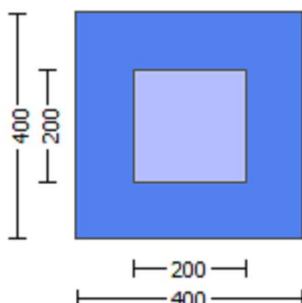
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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,  $\gamma = 0.80$ 
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
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,  $W = 400.00$ 
Internal Height,  $H = 200.00$ 
Internal Width,  $W = 200.00$ 
Cover Thickness,  $c = 25.00$ 
Element Length,  $L = 3000.00$ 
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness,  $t = 1.016$ 
Tensile Strength,  $f_{fu} = 1055.00$ 
Tensile Modulus,  $E_f = 64828.00$ 
Elongation,  $\epsilon_{fu} = 0.01$ 
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,  $M_a = 2.1072102E-010$ 
Shear Force,  $V_a = -1.0642330E-013$ 
EDGE -B-
Bending Moment,  $M_b = 1.0860180E-010$ 
Shear Force,  $V_b = 1.0642330E-013$ 
BOTH EDGES
Axial Force,  $F = -5974.507$ 

```

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1137.257$

-Compression: $As_c = 1539.38$

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 $V_R = 1.0 \cdot V_n = 585777.827$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 585777.827$

$V_{CoI} = 585777.827$

$k_n = 1.00$

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)

$M/V_d = 2.00$

$\mu_u = 2.1072102E-010$

$\nu_u = 1.0642330E-013$

$d = 0.8 \cdot h = 320.00$

$N_u = 5974.507$

$A_g = 160000.00$

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) = 188111.148

$f = 0.95$, 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: $\theta_1 = \theta_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

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

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 425154.451$

$b_w = 400.00$

displacement_ductility_demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 2.9773643E-021$

$y = (M_y * L_s / 3) / E_{eff} = 0.00653235 ((4.29), \text{Biskinis Phd})$

$M_y = 2.2575E+008$

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

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 1.7280E+013$

factor = 0.30

$A_g = 160000.00$

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

$N = 5974.507$

$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

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

$\phi_{y_{\text{ten}}} = 1.0810812E-005$

with $f_y = 555.56$

$d = 357.00$

$y = 0.280262$

$A = 0.01881926$

$B = 0.01057612$

with $p_t = 0.00796398$

$p_c = 0.00796398$

$p_v = 0.00281599$

$N = 5974.507$

$b = 400.00$

$\rho = 0.12044818$

$\phi_{y_{\text{comp}}} = 2.3130541E-005$

with $f_c^* (12.3, \text{ACI 440}) = 34.65043$

$f_c = 33.00$

$f_l = 0.93147527$

$b = 400.00$

$h = 400.00$

$A_g = 160000.00$

From (12.9), ACI 440: $k_a = 0.56518315$

$g = p_t + p_c + p_v = 0.01874396$

$r_c = 40.00$

$A_e / A_c = 0.56518315$

Effective FRP thickness, $t_f = N L * t * \cos(\theta_1) = 1.016$

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

$f_u = 0.01$

$E_f = 64828.00$

$E_c = 26999.444$

$y = 0.27975145$

$A = 0.0186534$

$B = 0.01050082$

with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Adequate Lap Length: $I_b / I_d \geq 1$

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

At local axis: 3

Integration Section: (a)

Calculation No. 4

column C1, Floor 1

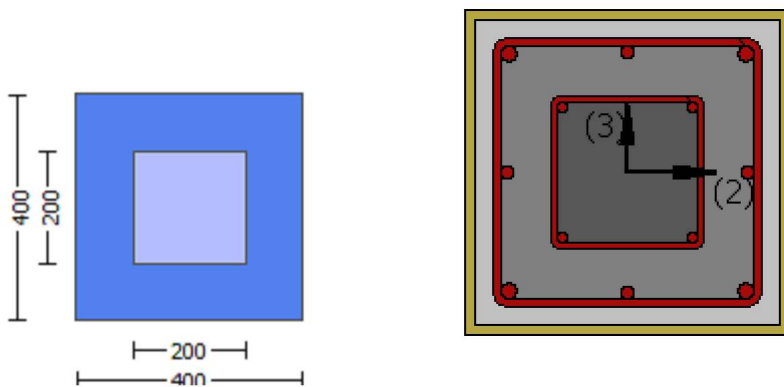
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\gamma = 0.80$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.13212
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{o,u}, \min \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $ef_u = 0.01$
 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, $V_a = 5.2204734E-032$
 EDGE -B-
 Shear Force, $V_b = -5.2204734E-032$
 BOTH EDGES
 Axial Force, $F = -5976.808$
 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, $V_e/V_r = 0.35962554$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.4650E+008$
 $\mu_{u1+} = 3.4650E+008$, 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
 $\mu_{u1-} = 3.4650E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.4650E+008$
 $\mu_{u2+} = 3.4650E+008$, 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
 $\mu_{u2-} = 3.4650E+008$, 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 μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 0.00010712$
 $M_u = 3.4650E+008$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01506636$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.01506636$$

$$\alpha_e ((5.4c), \text{TB DY}) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.08361288$$

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

$$f_x = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(\beta_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_f = 0.015$$

$$\alpha_{se} ((5.4d), \text{TB DY}) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$\alpha_{se1} = 0.24250288$$

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

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

$$b_{i2,1} = 462400.00$$

$$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$$

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

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

$$b_{i2,2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.07617$$

Expression ((5.4d), TB DY) 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)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

```

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A.5), TBDY), TBDY: cc = 0.00332119
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119

```


$c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

$\mu_u(4.9) = 0.16321971$
 $\mu_u = M_{Rc}(4.14) = 3.4650E+008$
 $u = \mu_u(4.1) = 0.00010712$

Calculation of ratio l_b/d

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

Calculation of μ_{u1} -

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

$u = 0.00010712$
 $\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha_{co}(5A.5, TBDY) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.01506636$
 $\mu_{we}((5.4c), TBDY) = \alpha_{se} * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = \alpha_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int})/A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o_1} = 340.00$
 $h_{o_1} = 340.00$

$bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.07617$
 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)

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

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

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

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

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

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

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

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

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636

```

$w_e ((5.4c), TBDY) = a_{se} \cdot \sigma_{h,min} \cdot f_{ywe}/f_{ce} + \min(f_x, f_y) = 0.08361288$
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)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.24250288$
 $a_{se1} = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$\sigma_{h,min} \cdot f_{ywe} = \min(\sigma_{h,x} \cdot f_{ywe}, \sigma_{h,y} \cdot f_{ywe}) = 3.07617$

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

$\sigma_{h,x} \cdot f_{ywe} = \sigma_{h1} \cdot f_{ywe1} + \sigma_{h2} \cdot f_{ywe2} = 3.07617$
 $\sigma_{h1} \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirrups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $\sigma_{h2} \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirrups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$\sigma_{h,y} \cdot f_{ywe} = \sigma_{h1} \cdot f_{ywe1} + \sigma_{h2} \cdot f_{ywe2} = 3.07617$
 $\sigma_{h1} \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirrups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $\sigma_{h2} \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirrups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $\alpha_c = 0.00332119$

$\alpha_c = \text{confinement factor} = 1.13212$

$\gamma_1 = 0.0025$

$\sigma_{h1} = 0.008$

```

ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
    c = confinement factor = 1.13212
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
    2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008

```

$$u = s_u(4.1) = 0.00010712$$

Calculation of ratio l_b/d

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

Calculation of μ_2

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

$$u = 0.00010712$$

$$\mu = 3.4650 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_c) = 0.01506636$$

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

$$\text{From (5.4b), TB DY: } \mu = 0.01506636$$

$$\mu_e((5.4c), \text{TB DY}) = \alpha * \mu_{\min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

where $\mu = \alpha * \mu_{\text{frp}}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.07683125$$

$$\alpha = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 870.5244$$

$$\mu_y = 0.07683125$$

$$\alpha = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L^* t \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

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

$$\alpha_e((5.4d), \text{TB DY}) = (\alpha e_1 A_{\text{ext}} + \alpha e_2 A_{\text{int}})/A_{\text{sec}} = 0.24250288$$

$$\alpha e_1 = 0.24250288$$

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

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

$$b_{i2,1} = 462400.00$$

$$\alpha e_2 = \text{Max}(\alpha e_1, \alpha e_2) = 0.24250288$$

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

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

$$b_{i2,2} = 147456.00$$

$$\mu_{\text{psh,min}} * f_{ywe} = \text{Min}(\mu_{\text{psh,x}} * f_{ywe}, \mu_{\text{psh,y}} * f_{ywe}) = 3.07617$$

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

$$\mu_{\text{psh,x}} * f_{ywe} = \mu_{\text{psh1}} * f_{ywe1} + \mu_{\text{ps2}} * f_{ywe2} = 3.07617$$

$$\mu_{\text{ps1}} (\text{external}) = (\alpha h_1 * h_1/s_1)/A_{\text{sec}} = 0.00392699$$

$Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$

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

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

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

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

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

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

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

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

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

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

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

with $fs2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$

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

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$

$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv , ftv , fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 694.45$
 with $Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b * d) * (fs1 / fc) = 0.16759354$
 $2 = Asl_com / (b * d) * (fs2 / fc) = 0.16759354$
 $v = Asl_mid / (b * d) * (fsv / fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_ten / (b * d) * (fs1 / fc) = 0.21525776$
 $2 = Asl_com / (b * d) * (fs2 / fc) = 0.21525776$
 $v = Asl_mid / (b * d) * (fsv / fc) = 0.07611324$

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

--->
 $v < vs_y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $Vr = Min(Vr1, Vr2) = 642326.47$

Calculation of Shear Strength at edge 1, $Vr1 = 642326.47$

$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$

$VColO = 642326.47$

$knl = 1$ (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 $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 9.9249344E-012$

$Vu = 5.2204734E-032$

$d = 0.8 * h = 320.00$

$Nu = 5976.808$

$Ag = 160000.00$

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:

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL \cdot t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 357.00
 $ffe ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 642326.47$
 $knl = 1$ (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)
 $M/Vd = 2.00$
 $\mu_u = 9.9249344E-012$
 $V_u = 5.2204734E-032$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = NL \cdot t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $b_w = 400.00$

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, $\phi = 0.80$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

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, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.13212
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o / l_{ou, min} \geq 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
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, $V_a = -4.7900285E-031$

EDGE -B-

Shear Force, $V_b = 4.7900285E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

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, $V_e/V_r = 0.35962554$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.4650E+008$

$M_{u1+} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.4650E+008$

$M_{u2+} = 3.4650E+008$, 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

$M_{u2-} = 3.4650E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 0.00010712$

$M_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

ϕ_{co} (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01506636$

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

From (5.4b), TBDY: $\phi_u = 0.01506636$

we ((5.4c), TBDY) = $a_s e^* \phi_{u,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$

where $\phi_{fx} = a_s^* \phi_{f,frp}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_{fx} = 0.07683125$

$a_s = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_{f,frp} = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{f,e} = 870.5244$

$f_y = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{f,e} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_f = 0.015$

$a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

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

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h_1 = 400.00$

$p_{s2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

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

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h_1 = 400.00$

$p_{s2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00332119$

c = confinement factor = 1.13212

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

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

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

$su_1 = 0.4 \cdot esu_1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_1_{nominal} = 0.08$,

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

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

with $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 694.45$

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

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

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

$lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$

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

with $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

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

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

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

$lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$

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

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

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.21525776$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.21525776$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 0.00010712$$
$$\mu = 3.4650 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$
$$d = 357.00$$
$$d' = 43.00$$
$$v = 0.00126831$$
$$N = 5976.808$$
$$f_c = 33.00$$
$$c_o(5A.5, TBDY) = 0.002$$
$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$
$$\mu_e((5.4c), TBDY) = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

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

$$\mu_x = 0.07683125$$
$$a_{se} = 0.57333333$$
$$b = 400.00$$
$$h = 400.00$$

From EC8 A.4.4.3(6), $\mu_{sh,min} = 2t_f/bw = 0.00508$

$$bw = 400.00$$

effective stress from (A.35), $f_{f,e} = 870.5244$

$$\mu_y = 0.07683125$$
$$a_{se} = 0.57333333$$
$$b = 400.00$$
$$h = 400.00$$

From EC8 A.4.4.3(6), $\mu_{sh,min} = 2t_f/bw = 0.00508$

$$bw = 400.00$$

effective stress from (A.35), $f_{f,e} = 870.5244$

$$R = 40.00$$

Effective FRP thickness, $t_f = N L^* t \cos(b_1) = 1.016$

$$f_{u,f} = 1055.00$$
$$E_f = 64828.00$$
$$u_{f,e} = 0.015$$
$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$
$$a_{se1} = 0.24250288$$
$$b_{o,1} = 340.00$$
$$h_{o,1} = 340.00$$
$$b_{i,1} = 462400.00$$
$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$
$$b_{o,2} = 192.00$$
$$h_{o,2} = 192.00$$
$$b_{i,2} = 147456.00$$
$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 3.07617$$

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)

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$
$$\mu_{sh1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$
$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

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

$$h_1 = 400.00$$
$$\mu_{sh2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$
$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

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

$$h_2 = 200.00$$

$$\mu_{sh,y} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$

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

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

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

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

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

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

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.

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

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

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.

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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.

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

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

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

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.16759354$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.16759354$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05925959$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 37.35991$$

$$cc (5A.5, TBDY) = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.16321971$$

$$\mu_u = M_{Rc} (4.14) = 3.4650E+008$$

$$u = s_u (4.1) = 0.00010712$$

Calculation of ratio l_b/d

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

Calculation of μ_{u2+}

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

$$u = 0.00010712$$

$$\mu_u = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, cc) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01506636$$

$$\text{we ((5.4c), TBDY) } = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

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

$$f_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

Effective FRP thickness, $t_f = NL * t * \cos(b1) = 1.016$

$f_u, f = 1055.00$

$E_f = 64828.00$

$u, f = 0.015$

$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$

$ase1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$ase2 = \max(ase1, ase2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$psh_{min} * F_{ywe} = \min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

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

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$

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

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$

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

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$A_{sec} = 160000.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

$c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

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

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

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

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

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

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and 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 $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.21525776$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MR_c (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

 Calculation of ratio l_b/l_d

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

 Calculation of Mu_2 -

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

$u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$

$d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha = 0.01506636$
 $\alpha_e ((5.4c), TBDY) = \alpha * \text{sh,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = \alpha * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{f,f} = 0.015$
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o,1} = 340.00$
 $h_{o,1} = 340.00$
 $b_{i,1} = 462400.00$
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$
 $b_{o,2} = 192.00$
 $h_{o,2} = 192.00$
 $b_{i,2} = 147456.00$

$p_{sh,min} * f_{ywe} = \text{Min}(p_{sh,x} * f_{ywe}, p_{sh,y} * f_{ywe}) = 3.07617$

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)

$p_{sh,x} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 3.07617$
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$
 No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$
 No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$p_{sh,y} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 3.07617$
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$
 No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$
 No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$

$s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$
 From ((5A.5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, \min = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$
 with $Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 37.35991$
 $cc (5A.5, \text{TBDY}) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.21525776$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $\mu (4.9) = 0.16321971$
 $\mu = M_{Rc} (4.14) = 3.4650E+008$
 $u = \mu (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 642326.47$
 $k_{nl} = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.3318154E-012$
 $V_u = 4.7900285E-031$
 $d = 0.8 * h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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, $= 45^\circ$ and $= -45^\circ$ 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, $t_{f1} = N_L * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$
 $V_{ColO} = 642326.47$
 $knl = 1$ (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)
 $M/Vd = 2.00$
 $\mu_u = 1.3318154E-012$
 $V_u = 4.7900285E-031$
 $d = 0.8 * h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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, $t_{f1} = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

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, $\phi = 0.80$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

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, $M = -1.7258E+007$

Shear Force, $V_2 = -5750.847$

Shear Force, $V_3 = -1.0642330E-013$

Axial Force, $F = -5974.507$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1137.257$

-Compression: $As_c = 1539.38$

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 $\phi_R = 1.0$ $\phi = 0.01806853$
 $\phi = \phi_y + \phi_p = 0.01806853$

- Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.01306853$ ((4.29), Biskinis Phd))
 $M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.88
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $A_g = 160000.00$
Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.507$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \min(\phi_{y,ten}, \phi_{y,com})$
 $\phi_{y,ten} = 1.0810812E-005$
with $f_y = 555.56$
 $d = 357.00$
 $\phi_y = 0.280262$
 $A = 0.01881926$
 $B = 0.01057612$
with $p_t = 0.00680078$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.507$
 $b = 400.00$
 $\alpha = 0.12044818$
 $\phi_{y,comp} = 2.3130541E-005$
with $f'_c * (12.3, (ACI 440)) = 34.65043$
 $f'_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e / A_c = 0.56518315$
Effective FRP thickness, $t_f = N L * t * \cos(b_1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $\phi_y = 0.27975145$
 $A = 0.0186534$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Adequate Lap Length: $I_b / I_d \geq 1$

- Calculation of ϕ_p -

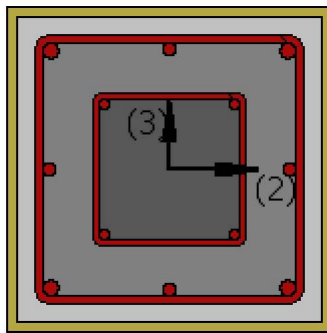
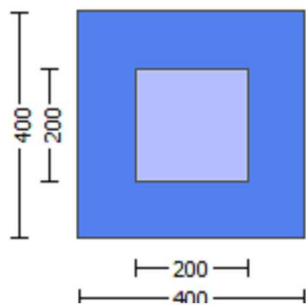
From table 10-8: $\phi_p = 0.005$
with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_{yE}/V_{ColOE} = 0.35962554$
 $d = d_{external} = 357.00$
 $s = s_{external} = 0.00$
 $t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00680078$
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
 $h_1 = 400.00$
 $s_1 = 100.00$
core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$
 $A_{v2} = 100.531$, 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.
 $NUD = 5974.507$
 $A_g = 160000.00$
 $f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section_area = 33.00$
 $f_{yIE} = (f_{y,ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 555.56$
 $f_{yIE} = (f_{y,ext_Trans_Reinf} \cdot Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} = 555.56$
 $\rho_l = Area_{Tot_Long_Rein} / (b \cdot d) = 0.01874396$
 $b = 400.00$
 $d = 357.00$
 $f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 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, $\gamma = 0.80$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $e_{fu} = 0.01$

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 = -1.7258E+007
Shear Force, Va = -5750.847
EDGE -B-
Bending Moment, Mb = 0.00815737
Shear Force, Vb = 5750.847
BOTH EDGES
Axial Force, F = -5974.507
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 = 585777.827
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 585777.827
VCol = 585777.827
knl = 1.00
displacement_ductility_demand = 0.11465513

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 = 0.00815737
Vu = 5750.847
d = 0.8*h = 320.00
Nu = 5974.507
Ag = 160000.00
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) = 188111.148
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: $\theta_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 425154.451$
 $b_w = 400.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta = 0.00014979$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00130647$ ((4.29), Biskinis Phd))
 $M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 1.7280E+013$
factor = 0.30
 $A_g = 160000.00$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$
 $N = 5974.507$
 $E_c * I_g = E_{c,\text{jacket}} * I_{g,\text{jacket}} + E_{c,\text{core}} * I_{g,\text{core}} = 5.7599E+013$

Calculation of Yielding Moment M_y

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

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.0810812E-005$
with $f_y = 555.56$
 $d = 357.00$
 $y = 0.280262$
 $A = 0.01881926$
 $B = 0.01057612$
with $p_t = 0.00796398$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.507$
 $b = 400.00$
 $\alpha = 0.12044818$
 $y_{\text{comp}} = 2.3130541E-005$
with $f_c^* (12.3, (\text{ACI 440})) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e / A_c = 0.56518315$
Effective FRP thickness, $t_f = N_L * t * \text{Cos}(b_1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975145$
 $A = 0.0186534$

B = 0.01050082
with Es = 200000.00

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

At local axis: 2

Integration Section: (b)

Calculation No. 6

column C1, Floor 1

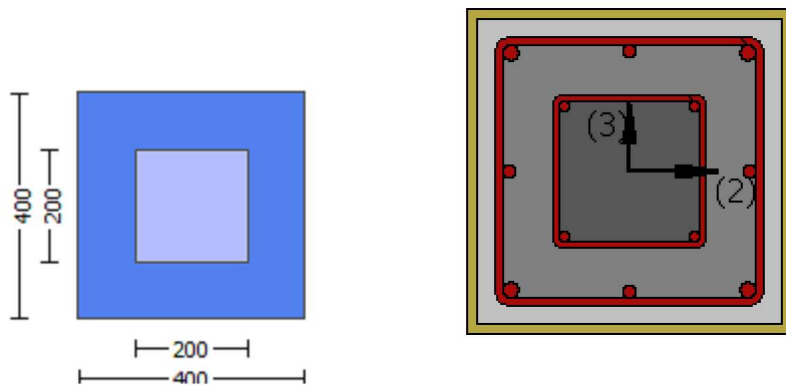
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\gamma = 0.80$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 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, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.13212
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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, $V_a = 5.2204734E-032$
 EDGE -B-
 Shear Force, $V_b = -5.2204734E-032$
 BOTH EDGES
 Axial Force, $F = -5976.808$
 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, $V_e/V_r = 0.35962554$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.4650E+008$
 $\mu_{u1+} = 3.4650E+008$, 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
 $\mu_{u1-} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.4650\text{E}+008$$

$M_{u2+} = 3.4650\text{E}+008$, 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

$M_{u2-} = 3.4650\text{E}+008$, 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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 0.00010712$$

$$M_u = 3.4650\text{E}+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01506636$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.01506636$$

$$\phi_{we} ((5.4c), \text{TB DY}) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$$

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

$$\phi_{fx} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\phi_{fy} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f,f} = 0.015$$

$$a_{se} ((5.4d), \text{TB DY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$\phi_{sh, \min} * f_{ywe} = \text{Min}(\phi_{sh, x} * f_{ywe}, \phi_{sh, y} * f_{ywe}) = 3.07617$$

Expression ((5.4d), TB DY) 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)

$$\phi_{sh, x} * f_{ywe} = \phi_{sh1} * f_{ywe1} + \phi_{sh2} * f_{ywe2} = 3.07617$$

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

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

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

$h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.16759354$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.16759354$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05925959$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 37.35991

cc (5A.5, TBDY) = 0.00332119

c = confinement factor = 1.13212

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.21525776$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.21525776$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.16321971

$Mu = MR_c$ (4.14) = 3.4650E+008

$u = su$ (4.1) = 0.00010712

Calculation of ratio lb/ld

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

Calculation of Mu_1 -

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

$u = 0.00010712$

$Mu = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01506636$

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

From (5.4b), TBDY: $cu = 0.01506636$

w_e ((5.4c), TBDY) = $ase \cdot sh_{min} \cdot fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.08361288$

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

$fx = 0.07683125$

$af = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$fy = 0.07683125$

$af = 0.57333333$

$b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $ff,e = 870.5244$

$R = 40.00$
 Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$psh_{,min}*F_{ywe} = Min(psh_{,x}*F_{ywe}, psh_{,y}*F_{ywe}) = 3.07617$
 Expression ((5.4d), TBDY) for $psh_{,min}*F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_{,x}*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_{,y}*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

with $fs1 = (fs_{jacket}*Asl_{ten,jacket} + fs_{core}*Asl_{ten,core})/Asl_{ten} = 694.45$

```

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu2+

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

$$\phi_u = 0.00010712$$

$$M_u = 3.4650 \times 10^8$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01506636$$

$$\phi_{ue} ((5.4c), \text{TBDY}) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$$

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

$$\phi_{fx} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\phi_{fy} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(\beta_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f,f} = 0.015$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

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

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

$$b_{i2,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

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

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

$$b_{i2,2} = 147456.00$$

$$\phi_{psh, \min} * f_{ywe} = \text{Min}(\phi_{psh, x} * f_{ywe}, \phi_{psh, y} * f_{ywe}) = 3.07617$$

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

$$\phi_{psh, x} * f_{ywe} = \phi_{psh1} * f_{ywe1} + \phi_{ps2} * f_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$\phi_{psh, y} * f_{ywe} = \phi_{psh1} * f_{ywe1} + \phi_{ps2} * f_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

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

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

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

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

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

$$\text{considering characteristic value } fsyv = fsv/1.2, \text{ from table 5.1, TBDY}$$

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

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

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

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

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.16759354$$

$$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fce) = 0.16759354$$

$$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fce) = 0.05925959$$

and confined core properties:

$$b = 340.00$$

$d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

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

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01506636$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$

$$ase((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.24250288$$

$$ase1 = 0.24250288$$

$$bo_1 = 340.00$$

$$ho_1 = 340.00$$

$$bi2_1 = 462400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.24250288$$

$$bo_2 = 192.00$$

$$ho_2 = 192.00$$

$$bi2_2 = 147456.00$$

$$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.07617$$

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)

$$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.07617$$

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

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

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00050265$$

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

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

$$h2 = 200.00$$

$$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.07617$$

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

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

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00050265$$

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

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

$$h2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

$$\text{Shear_factor} = 1.00$$

$$lo/lo_{min} = lb/l_d = 1.00$$

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

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

$$\text{Shear_factor} = 1.00$$

$$lo/lo_{min} = lb/l_{b,min} = 1.00$$

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

From table 5A.1, TBDY: $es_{2_nominal} = 0.08$,
 For calculation of $es_{2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.
 y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$
 with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/d = 1.00$
 $suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,
 considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $es_{uv_nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.
 y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.16759354$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.16759354$
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.21525776$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.21525776$
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.16321971$
 $\mu_u = MR_c (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

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

$V_{Col0} = 642326.47$

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

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

$= 1$ (normal-weight concrete)

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

MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9249344E-012$
 $\mu_v = 5.2204734E-032$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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 $\text{Col2} = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 188111.148$
 $f = 0.95$, 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, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col} ((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{Col0}$
 $V_{Col0} = 642326.47$
 $k_n l = 1$ (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)
 $M/Vd = 2.00$
 $\mu_u = 9.9249344E-012$
 $\mu_v = 5.2204734E-032$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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:

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
Vs2 is multiplied by Col2 = 0.00
 $s/d = 1.5625$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 188111.148$
 $f = 0.95$, 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: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe}((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $b_w = 400.00$

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, $\phi = 0.80$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

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, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.13212
Element Length, $L = 3000.00$
Secondary Member

Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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: 2
 EDGE -A-
 Shear Force, $V_a = -4.7900285E-031$
 EDGE -B-
 Shear Force, $V_b = 4.7900285E-031$
 BOTH EDGES
 Axial Force, $F = -5976.808$
 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, $V_e/V_r = 0.35962554$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
 with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.4650E+008$
 $Mu_{1+} = 3.4650E+008$, 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
 $Mu_{1-} = 3.4650E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.4650E+008$
 $Mu_{2+} = 3.4650E+008$, 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
 $Mu_{2-} = 3.4650E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 0.00010712$
 $M_u = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$

$N = 5976.808$
 $f_c = 33.00$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha = 0.01506636$
 $\alpha_e ((5.4c), TBDY) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = \alpha * \rho_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $\rho_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $\rho_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o,1} = 340.00$
 $h_{o,1} = 340.00$
 $b_{i,1} = 462400.00$
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$
 $b_{o,2} = 192.00$
 $h_{o,2} = 192.00$
 $b_{i,2} = 147456.00$
 $\rho_{sh, \min} * f_{ywe} = \text{Min}(\rho_{sh,x} * f_{ywe}, \rho_{sh,y} * f_{ywe}) = 3.07617$
 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)

$\rho_{sh,x} * f_{ywe} = \rho_{sh1} * f_{ywe1} + \rho_{sh2} * f_{ywe2} = 3.07617$
 $\rho_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$
 No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$
 No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$\rho_{sh,y} * f_{ywe} = \rho_{sh1} * f_{ywe1} + \rho_{sh2} * f_{ywe2} = 3.07617$
 $\rho_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$
 No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$
 No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$

```

fywe2 = 694.45
fce = 33.00
From ((5A.5), TBDY), TBDY: cc = 0.00332119
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfinedsd full section - Steel rupture

```

satisfies Eq. (4.3)

--->

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

--->

$\mu_u (4.9) = 0.16321971$

$\mu_u = M_{Rc} (4.14) = 3.4650E+008$

$u = \mu_u (4.1) = 0.00010712$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u1} -

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

$\mu_u = 0.00010712$

$\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.01506636$

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

From (5.4b), TBDY: $\mu_u = 0.01506636$

$\mu_u ((5.4c), TBDY) = \alpha * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$

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

$f_x = 0.07683125$

$\alpha_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$

$\alpha_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f,f} = 0.015$

$\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.24250288$

$\alpha_{se1} = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.07617$
 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)

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$

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

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

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

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

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

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

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

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

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

$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

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

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

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

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$

```

fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.08361288
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

fx = 0.07683125
af = 0.57333333

```


b = 400.00
h = 400.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$
bw = 400.00
effective stress from (A.35), $ff,e = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$
bw = 400.00
effective stress from (A.35), $ff,e = 870.5244$

R = 40.00
Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
 $ase2 = Max(ase1, ase2) = 0.24250288$
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
 $psh_{min}*F_{ywe} = Min(psh_x*F_{ywe}, psh_y*F_{ywe}) = 3.07617$
Expression ((5.4d), TBDY) for $psh_{min}*F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
h1 = 400.00
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
h2 = 200.00

$psh_y*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
h1 = 400.00
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
h2 = 200.00

$A_{sec} = 160000.00$
s1 = 100.00
s2 = 250.00
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
fce = 33.00
From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
c = confinement factor = 1.13212
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vsy2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/ld

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

Calculation of μ_2 -

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

$$\mu = 0.00010712$$

$$\mu = 3.4650 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\mu_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_0) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$

$$\mu_{we} \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

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

$$f_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L^* t \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$\mu_{f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

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

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

$$b_{i,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

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

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

$$b_{i,2} = 147456.00$$

$$p_{sh,min} * f_{ywe} = \text{Min}(p_{sh,x} * f_{ywe}, p_{sh,y} * f_{ywe}) = 3.07617$$

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)

$$p_{sh,x} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{sh2} * f_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00332119

c = confinement factor = 1.13212

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc \text{ (5A.2, TBDY)} = 37.35991$
 $cc \text{ (5A.5, TBDY)} = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.21525776$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.21525776$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su \text{ (4.9)} = 0.16321971$

$Mu = MRc \text{ (4.14)} = 3.4650E+008$

$u = su \text{ (4.1)} = 0.00010712$

Calculation of ratio lb/d

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 642326.47$

Calculation of Shear Strength at edge 1, $Vr1 = 642326.47$

$Vr1 = VCol \text{ ((10.3), ASCE 41-17)} = knl \cdot VCol0$

$VCol0 = 642326.47$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$Mu = 1.3318154E-012$

$Vu = 4.7900285E-031$

$d = 0.8 \cdot h = 320.00$

$Nu = 5976.808$

$Ag = 160000.00$

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 $Col2 = 0.00$

$s/d = 1.5625$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 188111.148$
 $f = 0.95$, 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, $tf1 = NL \cdot t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 357.00
 $ffe((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
 with $fu = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = knl \cdot V_{ColO}$
 $V_{ColO} = 642326.47$
 $knl = 1$ (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).

$\rho = 1$ (normal-weight concrete)
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot \text{Area}_{jacket} + fc'_{core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.3318154E-012$
 $\nu_u = 4.7900285E-031$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 188111.148$
 $f = 0.95$, 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, $tf1 = NL \cdot t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 357.00
 $ffe((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $b_w = 400.00$

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

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

Constant Properties

Knowledge Factor, $\gamma = 0.80$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 400.00$
External Width, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d \geq 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $\epsilon_{fu} = 0.01$
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, $M = 1.0860180E-010$
Shear Force, $V_2 = 5750.847$
Shear Force, $V_3 = 1.0642330E-013$
Axial Force, $F = -5974.507$
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: $Asl_{ten} = 1137.257$
 -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 $u_R = 1.0^*$ $u = 0.01153235$
 $u = y + p = 0.01153235$

- Calculation of y -

$y = (My * Ls / 3) / E_{eff} = 0.00653235$ ((4.29), Biskinis Phd))
 $My = 2.2575E+008$
 $Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $Ag = 160000.00$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.507$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0810812E-005$
 with $f_y = 555.56$
 $d = 357.00$
 $y = 0.280262$
 $A = 0.01881926$
 $B = 0.01057612$
 with $pt = 0.00680078$
 $pc = 0.00796398$
 $pv = 0.00281599$
 $N = 5974.507$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.3130541E-005$
 with $fc' (12.3, (ACI 440)) = 34.65043$
 $fc = 33.00$
 $fl = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $Ag = 160000.00$
 From (12.9), ACI 440: $ka = 0.56518315$
 $g = pt + pc + pv = 0.01874396$
 $rc = 40.00$
 $Ae/Ac = 0.56518315$
 Effective FRP thickness, $tf = NL * t * \text{Cos}(b1) = 1.016$
 effective strain from (12.5) and (12.12), $e_{fe} = 0.004$
 $fu = 0.01$
 $Ef = 64828.00$
 $Ec = 26999.444$

y = 0.27975145
A = 0.0186534
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.005

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1
shear control ratio VyE/VColOE = 0.35962554

d = d_external = 357.00

s = s_external = 0.00

t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00680078

jacket: s1 = Av1*h1/(s1*Ag) = 0.00392699

Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction

h1 = 400.00

s1 = 100.00

core: s2 = Av2*h2/(s2*Ag) = 0.00050265

Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction

h2 = 200.00

s2 = 250.00

The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution

where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

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

For the normalisation fs of jacket is used.

NUD = 5974.507

Ag = 160000.00

fcE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00

fyE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56

fyE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 555.56

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396

b = 400.00

d = 357.00

fcE = 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

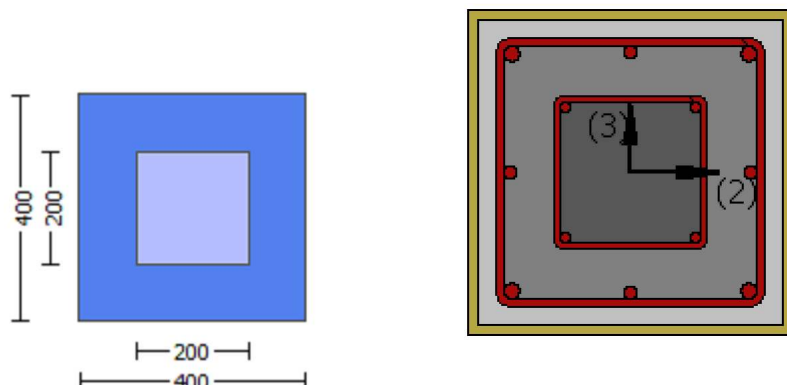
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

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, $\gamma = 0.80$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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, $M_a = 2.1072102E-010$
 Shear Force, $V_a = -1.0642330E-013$
 EDGE -B-
 Bending Moment, $M_b = 1.0860180E-010$
 Shear Force, $V_b = 1.0642330E-013$
 BOTH EDGES
 Axial Force, $F = -5974.507$
 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: $A_{sl,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 585777.827$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 585777.827$
 $V_{CoI} = 585777.827$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

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)
 $M/Vd = 2.00$
 $M_u = 1.0860180E-010$
 $V_u = 1.0642330E-013$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5974.507$
 $A_g = 160000.00$
 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

$$s/d = 1.5625$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 188111.148$$

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

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

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 θ_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

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

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

$$\text{total thickness per orientation, } t_{f1} = N_L * t / N_{\text{Dir}} = 1.016$$

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

$$f_{fe}((11-5), \text{ACI 440}) = 259.312$$

$$E_f = 64828.00$$

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

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 425154.451$$

$$b_w = 400.00$$

displacement_ductility_demand is calculated as δ / y

- Calculation of δ / y for END B -

for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 4.3619512E-023$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00653235 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 2.2575E+008$$

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

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.7280E+013$$

$$\text{factor} = 0.30$$

$$A_g = 160000.00$$

$$\text{Mean concrete strength: } f'_c = (f'_c_{\text{jacket}} * A_{\text{jacket}} + f'_c_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$$

$$N = 5974.507$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 5.7599E+013$$

Calculation of Yielding Moment M_y

Calculation of δ and M_y according to Annex 7 -

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

$$y_{\text{ten}} = 1.0810812E-005$$

$$\text{with } f_y = 555.56$$

$$d = 357.00$$

$$y = 0.280262$$

$$A = 0.01881926$$

$$B = 0.01057612$$

$$\text{with } p_t = 0.00796398$$

$$p_c = 0.00796398$$

$$p_v = 0.00281599$$

$$N = 5974.507$$

$$b = 400.00$$

$$r = 0.12044818$$

$$y_{\text{comp}} = 2.3130541E-005$$

$$\text{with } f'_c(12.3, \text{ACI 440}) = 34.65043$$

$$f_c = 33.00$$

$$f_l = 0.93147527$$

$$b = 400.00$$

$h = 400.00$
 $A_g = 160000.00$
 From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $rc = 40.00$
 $A_e/A_c = 0.56518315$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975145$
 $A = 0.0186534$
 $B = 0.01050082$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

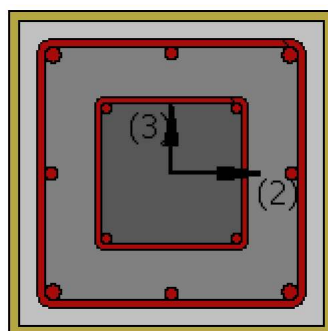
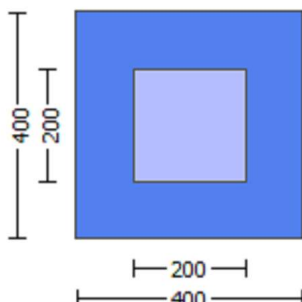
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\gamma = 0.80$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.13212

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

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, $V_a = 5.2204734E-032$

EDGE -B-

Shear Force, $V_b = -5.2204734E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

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 , $V_e/V_r = 0.35962554$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.4650\text{E}+008$

$M_{u1+} = 3.4650\text{E}+008$, 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

$M_{u1-} = 3.4650\text{E}+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.4650\text{E}+008$

$M_{u2+} = 3.4650\text{E}+008$, 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

$M_{u2-} = 3.4650\text{E}+008$, 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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00010712$

$M_u = 3.4650\text{E}+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$\nu = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01506636$

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

From (5.4b), TBDY: $\phi_u = 0.01506636$

$\phi_{we} \text{ ((5.4c), TBDY)} = a_{se} * \phi_{sh, \min} * f_{ywe}/f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$

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

$\phi_{fx} = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/b_w = 0.00508$

$b_w = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$\phi_{fy} = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/b_w = 0.00508$

$b_w = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = N L * t * \text{Cos}(\theta_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f} = 0.015$

$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o,1} = 340.00$

$h_{o,1} = 340.00$

$bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.07617$
 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)

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

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

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

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

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

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

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

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


```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636

```

$w_e ((5.4c), TBDY) = a_{se} \cdot \sigma_{h,min} \cdot f_{ywe}/f_{ce} + \min(f_x, f_y) = 0.08361288$
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)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.24250288$
 $a_{se1} = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$\sigma_{h,min} \cdot f_{ywe} = \min(\sigma_{h,x} \cdot f_{ywe}, \sigma_{h,y} \cdot f_{ywe}) = 3.07617$

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

$\sigma_{h,x} \cdot f_{ywe} = \sigma_{h1} \cdot f_{ywe1} + \sigma_{h2} \cdot f_{ywe2} = 3.07617$
 $\sigma_{h1} \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirrups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $\sigma_{h2} \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirrups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$\sigma_{h,y} \cdot f_{ywe} = \sigma_{h1} \cdot f_{ywe1} + \sigma_{h2} \cdot f_{ywe2} = 3.07617$
 $\sigma_{h1} \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirrups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $\sigma_{h2} \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirrups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

$c =$ confinement factor = 1.13212

$y_1 = 0.0025$

$\sigma_{h1} = 0.008$

```

ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
    c = confinement factor = 1.13212
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
    2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008

```

$$u = s_u(4.1) = 0.00010712$$

Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$$u = 0.00010712$$

$$\mu = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_c) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$

$$\mu_e((5.4c), TBDY) = \alpha * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

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

$$\mu_x = 0.07683125$$

$$\alpha = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 870.5244$$

$$\mu_y = 0.07683125$$

$$\alpha = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$\mu_{f} = 0.015$$

$$\alpha_e((5.4d), TBDY) = (\alpha_e1 * A_{ext} + \alpha_e2 * A_{int})/A_{sec} = 0.24250288$$

$$\alpha_e1 = 0.24250288$$

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

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

$$b_{i2,1} = 462400.00$$

$$\alpha_e2 = \text{Max}(\alpha_e1, \alpha_e2) = 0.24250288$$

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

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

$$b_{i2,2} = 147456.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 3.07617$$

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)

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$

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

$Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$

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

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

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

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

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

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

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

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

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

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$

$\text{su} = 0.4 \cdot \text{esuv_nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $\text{esuv_nominal} = 0.08$,
 considering characteristic value $\text{fsy} = \text{fsv}/1.2$, from table 5.1, TBDY
 For calculation of esuv_nominal and γ_v , $\text{sh}_v, \text{ft}_v, \text{fy}_v$, it is considered
 characteristic value $\text{fsy} = \text{fsv}/1.2$, from table 5.1, TBDY.
 γ_1 , $\text{sh}_1, \text{ft}_1, \text{fy}_1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with $\text{fs} = (\text{fs}_{\text{jacket}} \cdot \text{Asl}_{\text{mid,jacket}} + \text{fs}_{\text{mid}} \cdot \text{Asl}_{\text{mid,core}}) / \text{Asl}_{\text{mid}} = 694.45$
 with $\text{Es} = (\text{Es}_{\text{jacket}} \cdot \text{Asl}_{\text{mid,jacket}} + \text{Es}_{\text{mid}} \cdot \text{Asl}_{\text{mid,core}}) / \text{Asl}_{\text{mid}} = 200000.00$
 $1 = \text{Asl}_{\text{ten}} / (b \cdot d) \cdot (\text{fs}_1 / \text{fc}) = 0.16759354$
 $2 = \text{Asl}_{\text{com}} / (b \cdot d) \cdot (\text{fs}_2 / \text{fc}) = 0.16759354$
 $v = \text{Asl}_{\text{mid}} / (b \cdot d) \cdot (\text{fs}_v / \text{fc}) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $\text{fcc} (5A.2, \text{TBDY}) = 37.35991$
 $\text{cc} (5A.5, \text{TBDY}) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = \text{Asl}_{\text{ten}} / (b \cdot d) \cdot (\text{fs}_1 / \text{fc}) = 0.21525776$
 $2 = \text{Asl}_{\text{com}} / (b \cdot d) \cdot (\text{fs}_2 / \text{fc}) = 0.21525776$
 $v = \text{Asl}_{\text{mid}} / (b \cdot d) \cdot (\text{fs}_v / \text{fc}) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $\text{su} (4.9) = 0.16321971$
 $\text{Mu} = \text{MRc} (4.14) = 3.4650\text{E}+008$
 $u = \text{su} (4.1) = 0.00010712$

Calculation of ratio lb/ld

Adequate Lap Length: $\text{lb}/\text{ld} \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00010712$
 $\text{Mu} = 3.4650\text{E}+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $\text{fc} = 33.00$
 $\text{co} (5A.5, \text{TBDY}) = 0.002$
 Final value of cu : $\text{cu}^* = \text{shear_factor} \cdot \text{Max}(\text{cu}, \text{cc}) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\text{cu} = 0.01506636$
 $\text{we} ((5.4c), \text{TBDY}) = \text{ase} \cdot \text{sh}_{\text{min}} \cdot \text{fy}_{\text{we}} / \text{f}_{\text{ce}} + \text{Min}(\text{fx}, \text{fy}) = 0.08361288$
 where $f = \text{af} \cdot \text{pf} \cdot \text{ffe} / \text{f}_{\text{ce}}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

 $\text{fx} = 0.07683125$
 $\text{af} = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $\text{pf} = 2\text{tf}/\text{bw} = 0.00508$
 $\text{bw} = 400.00$
 effective stress from (A.35), $\text{ffe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.00508$
 $b_w = 400.00$
 effective stress from (A.35), $f_{f,e} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$
 $a_{se1} = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lo_{u,min} = lb/l_d = 1.00$
 $su_1 = 0.4 \cdot esu1_nominal ((5.5), TBDY) = 0.032$
 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.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 694.45$
 with $Es1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_{nominal} = 0.08$,
 For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$
 with $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.21525776$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.21525776$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

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

$V_{ColO} = 642326.47$

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

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

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} * Area_jacket + f'_{c_core} * Area_core) / Area_section = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9249344E-012$

$\nu_u = 5.2204734E-032$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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 $Col2 = 0.00$

$s/d = 1.5625$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 188111.148$

$f = 0.95$, 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, $t_{f1} = N_L * t / N_{oDir} = 1.016$

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

$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$

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

$V_{ColO} = 642326.47$

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

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

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} * Area_jacket + f'_{c_core} * Area_core) / Area_section = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9249344E-012$

$\nu_u = 5.2204734E-032$

$d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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: $a_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, a_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $b_w = 400.00$

 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, $\phi = 0.80$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

```

Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
#####
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13212
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00
-----

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force, Va = -4.7900285E-031
EDGE -B-
Shear Force, Vb = 4.7900285E-031
BOTH EDGES
Axial Force, F = -5976.808
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 , Ve/Vr = 0.35962554
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 230997.004
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.4650E+008
Mu1+ = 3.4650E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
Mu1- = 3.4650E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.4650E+008
Mu2+ = 3.4650E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
Mu2- = 3.4650E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
-----

```

Calculation of Mu1+

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

$$\mu = 0.00010712$$
$$Mu = 3.4650E+008$$

with full section properties:

$$b = 400.00$$
$$d = 357.00$$
$$d' = 43.00$$
$$v = 0.00126831$$
$$N = 5976.808$$
$$f_c = 33.00$$
$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$

$$\mu_e((5.4c), TBDY) = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

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

$$\mu_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\mu_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

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

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

$$b_{i,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

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

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

$$b_{i,2} = 147456.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 3.07617$$

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)

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$\mu_{sh2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$\mu_{sh,y} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$

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

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

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

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

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

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5A5), \text{TB DY}), \text{TB DY: } cc = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

$$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TB DY)} = 0.032$$

From table 5A.1, TB DY: esu1_nominal = 0.08,

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

$$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TB DY)} = 0.032$$

From table 5A.1, TB DY: 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, TB DY.

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

$$suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TB DY)} = 0.032$$

From table 5A.1, TB DY: esuv_nominal = 0.08,

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

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

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

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

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

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.16759354$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.16759354$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05925959$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 37.35991$$

$$cc (5A.5, TBDY) = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.16321971$$

$$\mu_u = M_{Rc} (4.14) = 3.4650E+008$$

$$u = s_u (4.1) = 0.00010712$$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u1} -

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

$$u = 0.00010712$$

$$\mu_u = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, cc) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01506636$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

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

$$f_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$

$f_u, f = 1055.00$

$E_f = 64828.00$

$u, f = 0.015$

$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$

$ase1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$ase2 = \max(ase1, ase2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$psh_{min} * F_{ywe} = \min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

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

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$

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

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$

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

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$A_{sec} = 160000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

$c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

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

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

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

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

with $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and 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 $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.21525776$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MR_c (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

 Calculation of ratio l_b/l_d

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

 Calculation of Mu_{2+}

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

$u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$


```

d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.08361288
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
-----
fx = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ffe = 870.5244
-----
fy = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ffe = 870.5244
-----
R = 40.00
Effective FRP thickness, tf = NL*t*cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.07617
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 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00
-----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00
-----
Asec = 160000.00
s1 = 100.00

```

$s_2 = 250.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$
 From ((5A.5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$
 with $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$
 with $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_v, sh_v, ft_v, fy_v , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$
 with $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 37.35991$
 $cc (5A.5, \text{TBDY}) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.21525776$

$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611324$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

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

--->
 $\mu_u (4.9) = 0.16321971$
 $\mu_u = M_{Rc} (4.14) = 3.4650E+008$
 $u = \mu_u (4.1) = 0.00010712$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u2} -

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

$u = 0.00010712$
 $\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha (5A.5, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.01506636$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.01506636$
 $\mu_{ue} ((5.4c), TBDY) = \alpha \cdot \text{sh}_{min} \cdot f_{ywe} / f_{ce} + \text{Min}(\mu_{fx}, \mu_{fy}) = 0.08361288$
where $\mu_f = \alpha \cdot \mu_{pf} \cdot f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\mu_{fx} = 0.07683125$
 $\mu_{af} = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $\mu_{pf} = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$\mu_{fy} = 0.07683125$
 $\mu_{af} = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $\mu_{pf} = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
Effective FRP thickness, $t_f = N \cdot t \cdot \cos(\beta_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{f,f} = 0.015$
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o_1} = 340.00$
 $h_{o_1} = 340.00$
 $b_{i2_1} = 462400.00$
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$
 $b_{o_2} = 192.00$

$ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.07617$
 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)

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/l_d = 1.00$

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

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

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

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

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

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

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/l_b,min = 1.00$

$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

$yv = 0.0025$

$shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$
 with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1,Vr2) = 642326.47$

Calculation of Shear Strength at edge 1, $Vr1 = 642326.47$

$Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO$

$VColO = 642326.47$

$knl = 1$ (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 $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 1.3318154E-012$

$Vu = 4.7900285E-031$

$d = 0.8*h = 320.00$

$Nu = 5976.808$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 = 279254.914$

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 188111.148

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, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$

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

f_{fe} ((11-5), ACI 440) = 259.312

$$E_f = 64828.00$$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$$b_w = 400.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$

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

$$V_{Col0} = 642326.47$$

$k_{nl} = 1$ (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).

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

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

$$M / V_d = 2.00$$

$$\mu_u = 1.3318154E-012$$

$$\nu_u = 4.7900285E-031$$

$$d = 0.8 \cdot h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

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

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 188111.148

$f = 0.95$, 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: $\theta_1 = b_1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, \theta_1)|, |Vf(-45, a_1)|)$, with:
 total thickness per orientation, $tf_1 = NL * t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 357.00
 ffe ((11-5), ACI 440) = 259.312
 $Ef = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
 with $fu = 0.01$
 From (11-11), ACI 440: $Vs + Vf \leq 488465.275$
 $bw = 400.00$

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, $\phi = 0.80$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b / d \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $ffu = 1055.00$
 Tensile Modulus, $Ef = 64828.00$
 Elongation, $efu = 0.01$
 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, $M = 0.00815737$

Shear Force, $V2 = 5750.847$

Shear Force, $V3 = 1.0642330E-013$

Axial Force, $F = -5974.507$

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: $As_{l,mid} = 402.1239$

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 $u_R = 1.0^*$ $u = 0.00630647$

$u = y + p = 0.00630647$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00130647$ ((4.29), Biskinis Phd))

$M_y = 2.2575E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$

factor = 0.30

$A_g = 160000.00$

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

$N = 5974.507$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

$y_{ten} = 1.0810812E-005$

with $f_y = 555.56$

$d = 357.00$

$y = 0.280262$

$A = 0.01881926$

$B = 0.01057612$

with $p_t = 0.00680078$

$p_c = 0.00796398$

$p_v = 0.00281599$

$N = 5974.507$

$b = 400.00$

" = 0.12044818

$y_{comp} = 2.3130541E-005$

with $fc^* (12.3, (ACI 440)) = 34.65043$

$fc = 33.00$

$f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
 From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e/A_c = 0.56518315$
 Effective FRP thickness, $t_f = N_L * t * \cos(b_1) = 1.016$
 effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $\gamma = 0.27975145$
 $A = 0.0186534$
 $B = 0.01050082$
 with $E_s = 200000.00$

Calculation of ratio l_b/l_d

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

- Calculation of p -

From table 10-8: $p = 0.005$

with:

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

shear control ratio $V_y E / V_{Col} O E = 0.35962554$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00680078$

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

$h_1 = 400.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00050265$

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

$h_2 = 200.00$

$s_2 = 250.00$

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

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

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

For the normalisation f_s of jacket is used.

$N_{UD} = 5974.507$

$A_g = 160000.00$

$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section_area = 33.00$

$f_{yIE} = (f_{y,ext_Long_Reinf} * Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} * Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 555.56$

$f_{yIE} = (f_{y,ext_Trans_Reinf} * Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} * Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} = 555.56$

$p_l = Area_{Tot_Long_Rein} / (b * d) = 0.01874396$

$b = 400.00$

$d = 357.00$

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

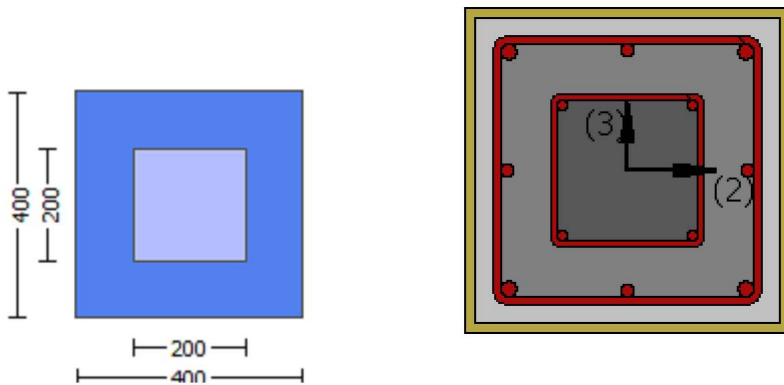
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 0.80$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $ε_{fu} = 0.01$
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, $M_a = -1.3810E+007$
Shear Force, $V_a = -4601.921$
EDGE -B-
Bending Moment, $M_b = 0.00652766$
Shear Force, $V_b = 4601.921$
BOTH EDGES
Axial Force, $F = -5974.966$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1137.257$
-Compression: $As_c = 1539.38$
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 $V_R = 1.0 \cdot V_n = 505466.184$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{CoI0} = 505466.184$
 $V_{CoI} = 505466.184$
 $knl = 1.00$
 $displacement_ductility_demand = 0.01735885$

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)
 $M/Vd = 4.00$
 $M_u = 1.3810E+007$
 $V_u = 4601.921$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5974.966$
 $A_g = 160000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 251327.412$

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) = 188111.148

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, $tf1 = NL \cdot t / \text{NoDir} = 1.016$

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

ffe ((11-5), ACI 440) = 259.312

$Ef = 64828.00$

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

with $fu = 0.01$

From (11-11), ACI 440: $Vs + Vf \leq 425154.451$

$bw = 400.00$

displacement_ductility_demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 0.00022685$

$y = (My \cdot Ls / 3) / Eleff = 0.01306853$ ((4.29), Biskinis Phd))

$My = 2.2575E+008$

$Ls = M/V$ (with $Ls > 0.1 \cdot L$ and $Ls < 2 \cdot L$) = 3000.88

From table 10.5, ASCE 41_17: $Eleff = \text{factor} \cdot Ec \cdot Ig = 1.7280E+013$

factor = 0.30

$Ag = 160000.00$

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

$N = 5974.966$

$Ec \cdot Ig = Ec_{\text{jacket}} \cdot Ig_{\text{jacket}} + Ec_{\text{core}} \cdot Ig_{\text{core}} = 5.7599E+013$

Calculation of Yielding Moment My

Calculation of δ and My according to Annex 7 -

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

$\delta_{\text{ten}} = 1.0810813E-005$

with $fy = 555.56$

$d = 357.00$

$y = 0.28026208$

$A = 0.01881927$

$B = 0.01057613$

with $pt = 0.00796398$

$pc = 0.00796398$

$pv = 0.00281599$

$N = 5974.966$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.3130538E-005$
 with $f_c^* (12.3, (ACI 440)) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
 From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $rc = 40.00$
 $A_e/A_c = 0.56518315$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975148$
 $A = 0.01865339$
 $B = 0.01050082$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

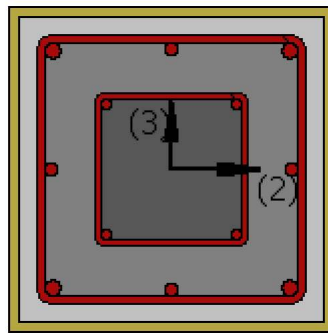
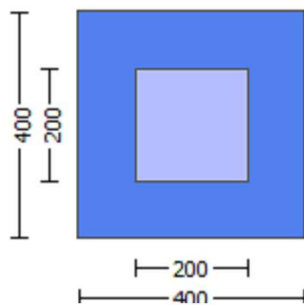
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 0.80$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.13212

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $e_{fu} = 0.01$

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, $V_a = 5.2204734E-032$

EDGE -B-

Shear Force, $V_b = -5.2204734E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

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, $V_e/V_r = 0.35962554$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.4650E+008$

$Mu_{1+} = 3.4650E+008$, 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

$Mu_{1-} = 3.4650E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.4650E+008$

$Mu_{2+} = 3.4650E+008$, 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

$Mu_{2-} = 3.4650E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 0.00010712$

$Mu = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

α_1 (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01506636$

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

From (5.4b), TBDY: $\phi_u = 0.01506636$

we ((5.4c), TBDY) = $\alpha_1 * \phi_{u,e} * \min(f_{ywe}/f_{ce} + \min(\phi_x, \phi_y)) = 0.08361288$

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

$\phi_x = 0.07683125$

$\alpha_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/b_w = 0.00508$
 $b_w = 400.00$
 effective stress from (A.35), $f_{f,e} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.24250288$
 $ase_1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi_2_1 = 462400.00$
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi_2_2 = 147456.00$
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.07617$

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)

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$
 $ps_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lo_{u,min} = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1_{nominal}((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1_{nominal} = 0.08$,
 For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, 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 $f_{s1} = (f_{sjacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 694.45$
with $E_{s1} = (E_{sjacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
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 $f_{s2} = (f_{sjacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 694.45$
with $E_{s2} = (E_{sjacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
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 $f_{sv} = (f_{sjacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 694.45$
with $E_{sv} = (E_{sjacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.16759354$
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.16759354$
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05925959$
and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.21525776$
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.21525776$
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07611324$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.16321971$
 $Mu = MR_c (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

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

Calculation of $Mu1$ -

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

$$\phi_u = 0.00010712$$

$$\mu = 3.4650 \times 10^8$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$\nu = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01506636$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01506636$$

$$\phi_{we} ((5.4c), TBDY) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$$

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

$$\phi_{fx} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\phi_{fy} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f,f} = 0.015$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

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

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

$$b_{i2,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

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

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

$$b_{i2,2} = 147456.00$$

$$\phi_{sh, \min} * f_{ywe} = \text{Min}(\phi_{sh, x} * f_{ywe}, \phi_{sh, y} * f_{ywe}) = 3.07617$$

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)

$$\phi_{sh, x} * f_{ywe} = \phi_{sh1} * f_{ywe1} + \phi_{sh2} * f_{ywe2} = 3.07617$$

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

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

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

$$h_1 = 400.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$\phi_{sh, y} * f_{ywe} = \phi_{sh1} * f_{ywe1} + \phi_{sh2} * f_{ywe2} = 3.07617$$

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

$Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

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

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

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

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

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

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

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

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

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

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

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.16759354$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.16759354$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

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

Calculation of Mu_{2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01506636$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$

$f_u, f = 1055.00$
 $E_f = 64828.00$
 $u, f = 0.015$
 $ase \ ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 3.07617$
 Expression ((5.4d), TBDY) for $psh, \min * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal \ ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$
 with $Es1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 0.00010712
Mu = 3.4650E+008

with full section properties:

b = 400.00
d = 357.00
d' = 43.00

$v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha_c = 0.01506636$
 $\alpha_{we} ((5.4c), TBDY) = \alpha^* \cdot \text{sh}_{\min} \cdot f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = \alpha^* \cdot \rho_f \cdot f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $\rho_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $\rho_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{f,f} = 0.015$
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o,1} = 340.00$
 $h_{o,1} = 340.00$
 $b_{i2,1} = 462400.00$
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$
 $b_{o,2} = 192.00$
 $h_{o,2} = 192.00$
 $b_{i2,2} = 147456.00$
 $\rho_{sh, \min} \cdot F_{ywe} = \text{Min}(\rho_{sh,x} \cdot F_{ywe}, \rho_{sh,y} \cdot F_{ywe}) = 3.07617$

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

$\rho_{sh,x} \cdot F_{ywe} = \rho_{sh1} \cdot F_{ywe1} + \rho_{sh2} \cdot F_{ywe2} = 3.07617$
 $\rho_{sh1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$
 No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$
 No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$\rho_{sh,y} \cdot F_{ywe} = \rho_{sh1} \cdot F_{ywe1} + \rho_{sh2} \cdot F_{ywe2} = 3.07617$
 $\rho_{sh1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$
 No stirrups, $n_{s,1} = 2.00$
 $h_1 = 400.00$
 $\rho_{sh2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$
 No stirrups, $n_{s,2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$

$fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1, \text{nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_1, \text{nominal} = 0.08$,
 For calculation of $esu_1, \text{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$
 with $Es_1 = (Es, \text{jacket} * Asl, \text{ten, jacket} + Es, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2, \text{nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_2, \text{nominal} = 0.08$,
 For calculation of $esu_2, \text{nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$
 with $Es_2 = (Es, \text{jacket} * Asl, \text{com, jacket} + Es, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv, \text{nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv, \text{nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv, \text{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs, \text{jacket} * Asl, \text{mid, jacket} + fs, \text{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$
 with $Es_v = (Es, \text{jacket} * Asl, \text{mid, jacket} + Es, \text{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 37.35991$
 $cc (5A.5, \text{TBDY}) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.21525776$
 $v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.07611324$

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

--->

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

--->

μ_u (4.9) = 0.16321971

$\mu_u = M_{Rc}$ (4.14) = 3.4650E+008

$u = \mu_u$ (4.1) = 0.00010712

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l V_{ColO}$

$V_{ColO} = 642326.47$

$k_n l = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 9.9249344E-012$

$V_u = 5.2204734E-032$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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) = 188111.148

$f = 0.95$, 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: $\theta = b_1 + 90^\circ = 90.00$

$V_f = \min(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

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

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl * V_{Col0}$
 $V_{Col0} = 642326.47$
 $knl = 1$ (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)
 $M / Vd = 2.00$
 $\mu_u = 9.9249344E-012$
 $V_u = 5.2204734E-032$
 $d = 0.8 * h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f \text{ ((11-3)-(11.4), ACI 440)} = 188111.148$
 $f = 0.95$, 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, $t_{f1} = N_L * t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} \text{ ((11-5), ACI 440)} = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

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, $\phi = 0.80$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.13212

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

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, $V_a = -4.7900285E-031$

EDGE -B-

Shear Force, $V_b = 4.7900285E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

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 , $V_e/V_r = 0.35962554$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.4650\text{E}+008$
 $\mu_{u1+} = 3.4650\text{E}+008$, 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
 $\mu_{u1-} = 3.4650\text{E}+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.4650\text{E}+008$
 $\mu_{u2+} = 3.4650\text{E}+008$, 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
 $\mu_{u2-} = 3.4650\text{E}+008$, 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 μ_{u1+}

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

$\phi_u = 0.00010712$
 $\mu_u = 3.4650\text{E}+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$

$f_c = 33.00$

ϕ_{co} (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01506636$

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

From (5.4b), TBDY: $\phi_{cu} = 0.01506636$

we ((5.4c), TBDY) = $a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$

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

 $\phi_{fx} = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $\phi_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$\phi_{fy} = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $\phi_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = N L^* t^* \cos(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.07617$
 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)

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

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

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

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

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

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

$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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

```

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+ Min( fx, fy) = 0.08361288
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```

fx = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

fy = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 40.00
Effective FRP thickness, tf = NL*t*cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.07617
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 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: cc = 0.00332119
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```


Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$$\mu = 0.00010712$$

$$\mu = 3.4650 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_c) = 0.01506636$$

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

$$\text{From (5.4b), TB DY: } \mu_c = 0.01506636$$

$$\mu_e ((5.4c), \text{TB DY}) = \alpha * \text{sh_min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

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

$$f_x = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

$$\alpha_e ((5.4d), \text{TB DY}) = (\alpha_1 * A_{ext} + \alpha_2 * A_{int}) / A_{sec} = 0.24250288$$

$$\alpha_1 = 0.24250288$$

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

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

$$b_{i2,1} = 462400.00$$

$$\alpha_2 = \text{Max}(\alpha_1, \alpha_2) = 0.24250288$$

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

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

$$b_{i2,2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.07617$$

Expression ((5.4d), TB DY) 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)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

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

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

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

$h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

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

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

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

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

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

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

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

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

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

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

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

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

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.16759354$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.16759354$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05925959$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 37.35991

cc (5A.5, TBDY) = 0.00332119

c = confinement factor = 1.13212

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.21525776$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.21525776$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.16321971

$Mu = MR_c$ (4.14) = 3.4650E+008

$u = su$ (4.1) = 0.00010712

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010712$

$Mu = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01506636$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.01506636$

w_e ((5.4c), TBDY) = $ase \cdot sh_{min} \cdot fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.08361288$

where $f = af \cdot pf \cdot f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$fx = 0.07683125$

$af = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$fy = 0.07683125$

$af = 0.57333333$

$b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $ff,e = 870.5244$

$R = 40.00$
 Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$psh, min*Fywe = Min(psh, x*Fywe, psh, y*Fywe) = 3.07617$
 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)

$psh, x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh, y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$A_{sec} = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$su1 = 0.4*esu1_nominal((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket}*Asl, ten, jacket + fs_{core}*Asl, ten, core)/Asl, ten = 694.45$

```

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 642326.47

Calculation of Shear Strength at edge 1, Vr1 = 642326.47

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 642326.47$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.3318154E-012$

$\nu_u = 4.7900285E-031$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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 $Col2 = 0.00$

$s/d = 1.5625$

$V_f ((11-3)-(11.4), ACI 440) = 188111.148$

$f = 0.95$, 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: $1 = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = N_L * t / \text{NoDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 357.00

$f_{fe} ((11-5), ACI 440) = 259.312$

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 642326.47$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.3318154E-012$

$\nu_u = 4.7900285E-031$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$
 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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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, $t_{f1} = N_L * t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $b_w = 400.00$

 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, $\phi = 0.80$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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, $M = 1.6663953E-010$
 Shear Force, $V_2 = -4601.921$
 Shear Force, $V_3 = -8.5161640E-014$
 Axial Force, $F = -5974.966$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_{lt} = 1137.257$
 -Compression: $As_{lc} = 1539.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{l,ten} = 1137.257$
 -Compression: $As_{l,com} = 1137.257$
 -Middle: $As_{l,mid} = 402.1239$
 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 $u_R = 1.0^*$ $u = 0.05698684$
 $u = y + p = 0.05698684$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00653235$ ((4.29), Biskinis Phd))
 $M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.966$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.0810813\text{E}-005$
with $f_y = 555.56$
 $d = 357.00$
 $y = 0.28026208$
 $A = 0.01881927$
 $B = 0.01057613$
with $p_t = 0.00680078$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.966$
 $b = 400.00$
 $\mu = 0.12044818$
 $y_{\text{comp}} = 2.3130538\text{E}-005$
with $f_c^* (12.3, \text{ACI } 440) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $rc = 40.00$
 $A_e/A_c = 0.56518315$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975148$
 $A = 0.01865339$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.05045449$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$

shear control ratio $V_y E / V_{col} E = 0.35962554$

$d = d_{\text{external}} = 357.00$

$s = s_{\text{external}} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00680078$

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

$h_1 = 400.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$

$A_{v2} = 100.531$, 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.

$N_{UD} = 5974.966$

$A_g = 160000.00$

$f_{cE} = (f_{c,jacket} \cdot \text{Area}_{jacket} + f_{c,core} \cdot \text{Area}_{core}) / \text{section_area} = 33.00$

$f_{yE} = (f_{y,ext_Long_Reinf} \cdot \text{Area}_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot \text{Area}_{int_Long_Reinf}) / \text{Area_Tot_Long_Rein} =$

555.56

$f_{ytE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 555.56$

$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.01874396$

$b = 400.00$

$d = 357.00$

$f_{cE} = 33.00$

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

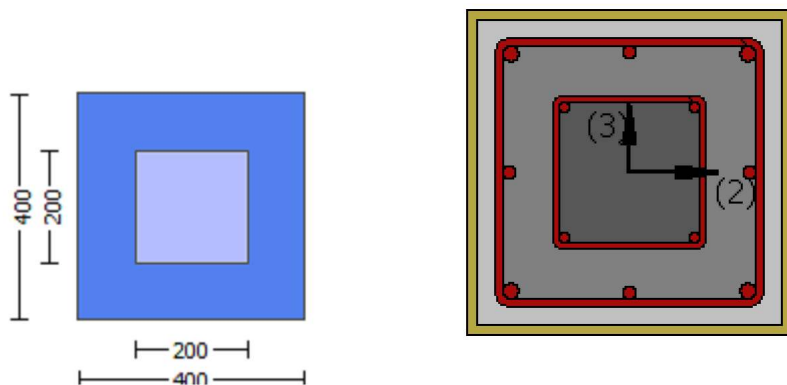
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 0.80$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of γ for displacement ductility demand,
 the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
 Deformation-Controlled Action (Table C7-1, ASCE 41-17).
 Jacket
 New material: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 Existing Column
 New material: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 #####
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $ef_u = 0.01$
 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, $M_a = 1.6663953E-010$
 Shear Force, $V_a = -8.5161640E-014$
 EDGE -B-
 Bending Moment, $M_b = 8.8887759E-011$
 Shear Force, $V_b = 8.5161640E-014$
 BOTH EDGES
 Axial Force, $F = -5974.966$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1137.257$
 -Compression: $As_c = 1539.38$
 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 $V_R = 1.0 \cdot V_n = 585777.918$

Vn ((10.3), ASCE 41-17) = knl*VColO = 585777.918

VCol = 585777.918

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 = 1.6663953E-010

Vu = 8.5161640E-014

d = 0.8*h = 320.00

Nu = 5974.966

Ag = 160000.00

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) = 188111.148

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 = 1.016

dfv = d (figure 11.2, ACI 440) = 357.00

ffe ((11-5), ACI 440) = 259.312

Ef = 64828.00

fe = 0.004, from (11.6a), ACI 440

with fu = 0.01

From (11-11), ACI 440: Vs + Vf <= 425154.451

bw = 400.00

displacement_ductility_demand is calculated as / y

- Calculation of / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation = 2.3825350E-021

y = (My*Ls/3)/Eleff = 0.00653235 ((4.29), Biskinis Phd)

My = 2.2575E+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 = 1.7280E+013

factor = 0.30

Ag = 160000.00

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00

N = 5974.966

$$E_c I_g = E_{c_jacket} I_{g_jacket} + E_{c_core} I_{g_core} = 5.7599E+013$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0810813E-005$
 with $f_y = 555.56$
 $d = 357.00$
 $y = 0.28026208$
 $A = 0.01881927$
 $B = 0.01057613$
 with $p_t = 0.00796398$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.966$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.3130538E-005$
 with $f_c^* (12.3, (ACI 440)) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
 From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e/A_c = 0.56518315$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975148$
 $A = 0.01865339$
 $B = 0.01050082$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

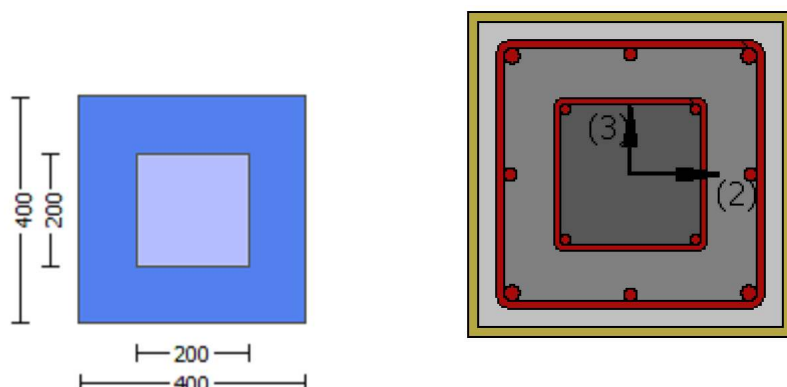
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\gamma = 0.80$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.13212

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

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, $V_a = 5.2204734E-032$

EDGE -B-

Shear Force, $V_b = -5.2204734E-032$

BOTH EDGES

Axial Force, $F = -5976.808$

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, $V_e/V_r = 0.35962554$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.4650E+008$

$\mu_{u1+} = 3.4650E+008$, 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

$\mu_{u1-} = 3.4650E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.4650E+008$

$\mu_{u2+} = 3.4650E+008$, 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

$\mu_{u2-} = 3.4650E+008$, 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 μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00010712$

$\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$\phi_o (5A.5, TBDY) = 0.002$

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01506636$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01506636$

w_e ((5.4c), TBDY) = $a_s * \text{sh_min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$

where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = NL * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

a_s ((5.4d), TBDY) = $(a_{s1} * A_{ext} + a_{s2} * A_{int})/A_{sec} = 0.24250288$

$a_{s1} = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$a_{s2} = \text{Max}(a_{s1}, a_{s2}) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$p_{sh,min} * f_{ywe} = \text{Min}(p_{sh,x} * f_{ywe}, p_{sh,y} * f_{ywe}) = 3.07617$

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)

$p_{sh,x} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 3.07617$

$ps1$ (external) = $(A_{sh1} * h_1/s_1)/A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h_1 = 400.00$

$ps2$ (internal) = $(A_{sh2} * h_2/s_2)/A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h_2 = 200.00$

$p_{sh,y} * f_{ywe} = p_{sh1} * f_{ywe1} + p_{s2} * f_{ywe2} = 3.07617$

$ps1$ (external) = $(A_{sh1} * h_1/s_1)/A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h_1 = 400.00$

$ps2$ (internal) = $(A_{sh2} * h_2/s_2)/A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$


```

c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

```

--->

$$s_u(4.9) = 0.16321971$$

$$M_u = M_{Rc}(4.14) = 3.4650E+008$$

$$u = s_u(4.1) = 0.00010712$$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of M_{u1} -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010712$$

$$M_u = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\phi_{co}(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01506636$$

$$\phi_{we}((5.4c), TBDY) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$$

where $\phi_f = a_f * \phi_{pf} * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\phi_{fy} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f,f} = 0.015$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i2,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i2,2} = 147456.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 3.07617$$

Expression ((5.4d), TBDY) for $\phi_{sh, \min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs_jacket \cdot Asl, ten, jacket + fs_core \cdot Asl, ten, core) / Asl, ten = 694.45$

with $Es1 = (Es_jacket \cdot Asl, ten, jacket + Es_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs_jacket \cdot Asl, com, jacket + fs_core \cdot Asl, com, core) / Asl, com = 694.45$

with $Es2 = (Es_jacket \cdot Asl, com, jacket + Es_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and 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 $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.16759354$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.16759354$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.21525776$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.21525776$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_{2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01506636$
 $we ((5.4c), TBDY) = ase * sh_{min} * fy_{we} / fce + Min(fx, fy) = 0.08361288$
 where $f = af * pf * ffe / fce$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

 $fx = 0.07683125$
 $af = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$

bw = 400.00
effective stress from (A.35), $f_{f,e} = 870.5244$

fy = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
bw = 400.00
effective stress from (A.35), $f_{f,e} = 870.5244$

R = 40.00
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase \text{ ((5.4d), TBDY)} = (ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.24250288$
 $ase_1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $lo/lo_{u,min} = lb/ld = 1.00$
 $su_1 = 0.4 \cdot esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs_jacket \cdot Asl_ten_jacket + fs_core \cdot Asl_ten_core) / Asl_ten = 694.45$
with $Es1 = (Es_jacket \cdot Asl_ten_jacket + Es_core \cdot Asl_ten_core) / Asl_ten = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu2_nominal = 0.08$,
For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs2 = (fs_jacket \cdot Asl_com_jacket + fs_core \cdot Asl_com_core) / Asl_com = 694.45$
with $Es2 = (Es_jacket \cdot Asl_com_jacket + Es_core \cdot Asl_com_core) / Asl_com = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (fs_jacket \cdot Asl_mid_jacket + fs_mid \cdot Asl_mid_core) / Asl_mid = 694.45$
with $Es_v = (Es_jacket \cdot Asl_mid_jacket + Es_mid \cdot Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.05925959$
and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.21525776$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.21525776$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.07611324$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu2-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00010712$$

$$Mu = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_c) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$

$$\mu_e \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

where $\mu = a_f * \mu_{pf} * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\mu_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$\mu_{f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i,2} = 147456.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 3.07617$$

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)

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$

$$\mu_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirrups, } n_{s,2} = 2.00$$

$$h_2 = 200.00$$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00332119

c = confinement factor = 1.13212

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.16759354$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.16759354$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05925959$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 37.35991$$

$$c_c (5A.5, TBDY) = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.16321971$$

$$M_u = M_{Rc} (4.14) = 3.4650E+008$$

$$u = s_u (4.1) = 0.00010712$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$$V_{Col0} = 642326.47$$

$k_{nl} = 1$ (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)

$$M/Vd = 2.00$$

$$M_u = 9.9249344E-012$$

$$V_u = 5.2204734E-032$$

$$d = 0.8 * h = 320.00$$

$$N_u = 5976.808$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

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 $Col2 = 0.00$

$$s/d = 1.5625$$

$$V_f ((11-3)-(11.4), ACI 440) = 188111.148$$

$f = 0.95$, 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, $tf1 = NL \cdot t / \text{NoDir} = 1.016$

$dfv = d$ (figure 11.2, ACI 440) = 357.00

ffe ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$fe = 0.004$, from (11.6a), ACI 440

with $fu = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $knl \cdot V_{Col0}$

$V_{Col0} = 642326.47$

$knl = 1$ (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)

$M/Vd = 2.00$

$\mu_u = 9.9249344E-012$

$\nu_u = 5.2204734E-032$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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) = 188111.148

$f = 0.95$, 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, $tf1 = NL \cdot t / \text{NoDir} = 1.016$

$dfv = d$ (figure 11.2, ACI 440) = 357.00

ffe ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$fe = 0.004$, from (11.6a), ACI 440

with $fu = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$bw = 400.00$

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, $\gamma = 0.80$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

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, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.13212
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $\epsilon_{fu} = 0.01$
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, $V_a = -4.7900285E-031$

EDGE -B-

Shear Force, $V_b = 4.7900285E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

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, $V_e/V_r = 0.35962554$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.4650E+008$

$Mu_{1+} = 3.4650E+008$, 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

$Mu_{1-} = 3.4650E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.4650E+008$

$Mu_{2+} = 3.4650E+008$, 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

$Mu_{2-} = 3.4650E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00010712$

$M_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$\phi_{co} (5A.5, TBDY) = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01506636$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01506636$

$\phi_{we} ((5.4c), TBDY) = a_s e^* \phi_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$

where $\phi_{fx} = a_s^* \phi_{pf} * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_{fx} = 0.07683125$

$a_s = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/b_w = 0.00508$

$b_w = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$\phi_{fy} = 0.07683125$

$a_s = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/b_w = 0.00508$

$b_w = 400.00$

effective stress from (A.35), $f_{f,e} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f,e} = 0.015$

$a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o,1} = 340.00$

$h_{o,1} = 340.00$

$b_{i2,1} = 462400.00$

$a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$

$b_{o,2} = 192.00$

$h_{o,2} = 192.00$

$b_{i2,2} = 147456.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.07617$

$ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$

No stirrups, $n_{s,1} = 2.00$

$h_1 = 400.00$

$ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$

No stirrups, $n_{s,2} = 2.00$

$h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.07617$

$ps_1 \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir,1} \cdot n_{s,1} = 157.0796$

No stirrups, $n_{s,1} = 2.00$

$h_1 = 400.00$

$ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir,2} \cdot n_{s,2} = 100.531$

No stirrups, $n_{s,2} = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00332119$

$c = \text{confinement factor} = 1.13212$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o / l_{ou,min} = l_b / l_d = 1.00$

$su_1 = 0.4 \cdot esu_{1,nominal}((5.5), TBDY) = 0.032$

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 $fs_1 = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 694.45$

with $Es_1 = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

```

fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
    c = confinement factor = 1.13212
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
    2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 0.00010712
Mu = 3.4650E+008

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\alpha (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \alpha = 0.01506636$$

$$w_e ((5.4c), \text{TB DY}) = \alpha s_e * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

where $f = \alpha f_p f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.07683125$$

$$\alpha f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$\alpha f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L^* t \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha s_e ((5.4d), \text{TB DY}) = (\alpha s_1 A_{ext} + \alpha s_2 A_{int}) / A_{sec} = 0.24250288$$

$$\alpha s_1 = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i2,1} = 462400.00$$

$$\alpha s_2 = \text{Max}(\alpha s_1, \alpha s_2) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i2,2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

Expression ((5.4d), TB DY) 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)

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirrups, } n_{s,2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirrups, } n_{s,2} = 2.00$$

$$h_2 = 200.00$$

```

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A.5), TBDY), TBDY: cc = 0.00332119
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119

```


$c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->

$\mu_u(4.9) = 0.16321971$
 $\mu_u = M_{Rc}(4.14) = 3.4650E+008$
 $u = \mu_u(4.1) = 0.00010712$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{u2+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010712$
 $\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha_{co}(5A.5, TBDY) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.01506636$
 $\mu_{we}((5.4c), TBDY) = \alpha_{se} * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = \alpha_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.00508$
 $b_w = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.00508$
 $b_w = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = N L * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int})/A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o_1} = 340.00$
 $h_{o_1} = 340.00$

$bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.07617$
 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)

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, min = lb/l_d = 1.00$

$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 694.45$

with $Es1 = (Es, jacket * Asl, ten, jacket + Es, core * Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, min = lb/l_b, min = 1.00$

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636

```

$w_e ((5.4c), TBDY) = a_{se} \cdot \sigma_{h,min} \cdot f_{ywe}/f_{ce} + \min(f_x, f_y) = 0.08361288$
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)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.24250288$
 $a_{se1} = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$\sigma_{h,min} \cdot f_{ywe} = \min(\sigma_{h,x} \cdot f_{ywe}, \sigma_{h,y} \cdot f_{ywe}) = 3.07617$

Expression ((5.4d), TBDY) for $\sigma_{h,min} \cdot f_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\sigma_{h,x} \cdot f_{ywe} = \sigma_{h1} \cdot f_{ywe1} + \sigma_{h2} \cdot f_{ywe2} = 3.07617$
 $\sigma_{h1} \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirrups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $\sigma_{h2} \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirrups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$\sigma_{h,y} \cdot f_{ywe} = \sigma_{h1} \cdot f_{ywe1} + \sigma_{h2} \cdot f_{ywe2} = 3.07617$
 $\sigma_{h1} \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirrups, $n_{s_1} = 2.00$
 $h_1 = 400.00$
 $\sigma_{h2} \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirrups, $n_{s_2} = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

$c =$ confinement factor = 1.13212

$y_1 = 0.0025$

$\sigma_{h1} = 0.008$

```

ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
    c = confinement factor = 1.13212
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
    2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008

```

$$u = s_u(4.1) = 0.00010712$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

$V_{r1} = V_{Col}((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 642326.47$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} * Area_jacket + f'_{c_core} * Area_core) / Area_section = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.3318154E-012$

$\mu_v = 4.7900285E-031$

$d = 0.8 * h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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 $Col2 = 0.00$

$s/d = 1.5625$

$V_f((11-3)-(11.4), ACI 440) = 188111.148$

$f = 0.95$, 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: $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = N_L * t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 357.00

$f_{fe}((11-5), ACI 440) = 259.312$

$E_f = 64828.00$

$f_{fe} = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$

$V_{r2} = V_{Col}((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 642326.47$

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.3318154E-012$

$\nu_u = 4.7900285E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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), ACI 440) = 188111.148

$f = 0.95$, 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, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 357.00

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 488465.275$

$b_w = 400.00$

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, $\gamma = 0.80$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 400.00$
 External Width, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/d \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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, $M = -1.3810E+007$
 Shear Force, $V_2 = -4601.921$
 Shear Force, $V_3 = -8.5161640E-014$
 Axial Force, $F = -5974.966$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1137.257$
 -Compression: $As_c = 1539.38$
 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 $u_R = 1.0^*$ $u = 0.06352302$
 $u = y + p = 0.06352302$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01306853 ((4.29), \text{Biskinis Phd})$

$M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1*L$ and $L_s < 2*L$) = 3000.88
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $A_g = 160000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.966$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0810813E-005$
 with $f_y = 555.56$
 $d = 357.00$
 $y = 0.28026208$
 $A = 0.01881927$
 $B = 0.01057613$
 with $p_t = 0.00680078$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.966$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.3130538E-005$
 with f_c^* (12.3, (ACI 440)) = 34.65043
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
 From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e/A_c = 0.56518315$
 Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.016$
 effective strain from (12.5) and (12.12), $e_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975148$
 $A = 0.01865339$
 $B = 0.01050082$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.05045449$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$
 shear control ratio $V_y E / V_{col} I_E = 0.35962554$
 $d = d_{external} = 357.00$
 $s = s_{external} = 0.00$
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00680078$
 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
 $h_1 = 400.00$

$$s1 = 100.00$$

$$\text{core: } s2 = A_{v2} \cdot h^2 / (s2 \cdot A_g) = 0.00050265$$

$A_{v2} = 100.531$, 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.

$$N_{UD} = 5974.966$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c_jacket} \cdot A_{jacket} + f_{c_core} \cdot A_{core}) / \text{section_area} = 33.00$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot A_{ext_Long_Reinf} + f_{y_int_Long_Reinf} \cdot A_{int_Long_Reinf}) / A_{Tot_Long_Rein} = 555.56$$

$$f_{yTE} = (f_{y_ext_Trans_Reinf} \cdot A_{ext_Trans_Reinf} + f_{y_int_Trans_Reinf} \cdot A_{int_Trans_Reinf}) / A_{Tot_Trans_Rein} = 555.56$$

$$\rho_l = A_{Tot_Long_Rein} / (b \cdot d) = 0.01874396$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

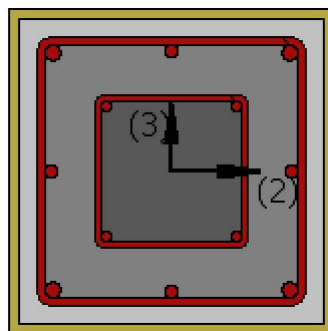
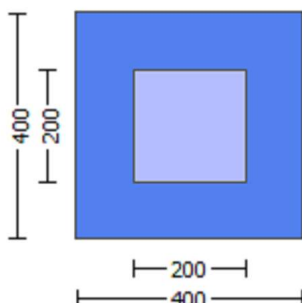
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity 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,  $\gamma = 0.80$ 
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
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,  $W = 400.00$ 
Internal Height,  $H = 200.00$ 
Internal Width,  $W = 200.00$ 
Cover Thickness,  $c = 25.00$ 
Element Length,  $L = 3000.00$ 
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness,  $t = 1.016$ 
Tensile Strength,  $f_{fu} = 1055.00$ 
Tensile Modulus,  $E_f = 64828.00$ 
Elongation,  $\epsilon_{fu} = 0.01$ 
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,  $M_a = -1.3810E+007$ 
Shear Force,  $V_a = -4601.921$ 
EDGE -B-
Bending Moment,  $M_b = 0.00652766$ 
Shear Force,  $V_b = 4601.921$ 
BOTH EDGES
Axial Force,  $F = -5974.966$ 

```

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 $V_R = 1.0 \cdot V_n = 585777.918$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 585777.918$

$V_{CoI} = 585777.918$

$k_n = 1.00$

displacement_ductility_demand = 0.09174886

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)

$M / V_d = 2.00$

$\mu_u = 0.00652766$

$V_u = 4601.921$

$d = 0.8 \cdot h = 320.00$

$N_u = 5974.966$

$A_g = 160000.00$

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) = 188111.148

$f = 0.95$, 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, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 357.00

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 425154.451$

$b_w = 400.00$

displacement_ductility_demand is calculated as δ / y

- Calculation of ϕ_y for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta = 0.00011987$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00130647$ ((4.29), Biskinis Phd))
 $M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $A_g = 160000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.966$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(\phi_{y,ten}, \phi_{y,com})$
 $\phi_{y,ten} = 1.0810813E-005$
with $f_y = 555.56$
 $d = 357.00$
 $y = 0.28026208$
 $A = 0.01881927$
 $B = 0.01057613$
with $p_t = 0.00796398$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.966$
 $b = 400.00$
 $\rho = 0.12044818$
 $\phi_{y,comp} = 2.3130538E-005$
with $f_c^* (12.3, (ACI 440)) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e / A_c = 0.56518315$
Effective FRP thickness, $t_f = N L * t * \cos(\theta_1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975148$
 $A = 0.01865339$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Adequate Lap Length: $I_b / I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 14

column C1, Floor 1

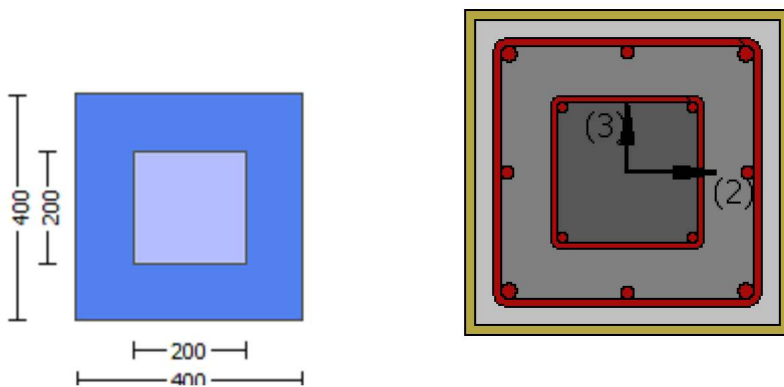
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\gamma = 0.80$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.13212
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{o,u}, \min \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $ef_u = 0.01$
 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, $V_a = 5.2204734E-032$
 EDGE -B-
 Shear Force, $V_b = -5.2204734E-032$
 BOTH EDGES
 Axial Force, $F = -5976.808$
 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, $V_e/V_r = 0.35962554$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.4650E+008$
 $\mu_{u1+} = 3.4650E+008$, 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
 $\mu_{u1-} = 3.4650E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.4650E+008$
 $\mu_{u2+} = 3.4650E+008$, 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
 $\mu_{u2-} = 3.4650E+008$, 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 μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 0.00010712$
 $M_u = 3.4650E+008$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\alpha (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \alpha: \alpha = \text{shear_factor} * \text{Max}(\alpha_c, \alpha_s) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \alpha_c = 0.01506636$$

$$\alpha_s ((5.4c), \text{TB DY}) = \alpha_s * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.08361288$$

where $\alpha = \alpha_s * \rho_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(\beta_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f,f} = 0.015$$

$$\alpha_s ((5.4d), \text{TB DY}) = (\alpha_{s1} * A_{ext} + \alpha_{s2} * A_{int}) / A_{sec} = 0.24250288$$

$$\alpha_{s1} = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i,2,1} = 462400.00$$

$$\alpha_{s2} = \text{Max}(\alpha_{s1}, \alpha_{s2}) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i,2,2} = 147456.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 3.07617$$

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)

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 3.07617$$

$$\text{ps}_1 (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$\text{ps}_2 (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirrups, } n_{s,2} = 2.00$$

$$h_2 = 200.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 3.07617$$

$$\text{ps}_1 (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$\text{ps}_2 (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirrups, } n_{s,2} = 2.00$$

$$h_2 = 200.00$$


```

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A.5), TBDY), TBDY: cc = 0.00332119
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119

```

$c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->

$\mu_u(4.9) = 0.16321971$
 $\mu_u = M_{Rc}(4.14) = 3.4650E+008$
 $u = \mu_u(4.1) = 0.00010712$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u1} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010712$
 $\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $\alpha_{co}(5A.5, TBDY) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.01506636$
 $\mu_{we}((5.4c), TBDY) = \alpha_{se} * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = \alpha_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $\alpha_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = N L * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int})/A_{sec} = 0.24250288$
 $\alpha_{se1} = 0.24250288$
 $b_{o_1} = 340.00$
 $h_{o_1} = 340.00$

$bi2_1 = 462400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$
 $psh, min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.07617$
 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)

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, min = lb/ld = 1.00$

$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 694.45$

with $Es1 = (Es, jacket * Asl, ten, jacket + Es, core * Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by 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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636

```

$w_e ((5.4c), TBDY) = a_{se} \cdot s_{h,min} \cdot f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
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)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int})/A_{sec} = 0.24250288$
 $a_{se1} = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$
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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (A_{sh1} \cdot h_1/s_1)/A_{sec} = 0.00392699$
 $A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
 $h_1 = 400.00$
 $ps2 \text{ (internal)} = (A_{sh2} \cdot h_2/s_2)/A_{sec} = 0.00050265$
 $A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
 $h_2 = 200.00$

$A_{sec} = 160000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$
From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $y_1 = 0.0025$
 $sh_1 = 0.008$

```

ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
    c = confinement factor = 1.13212
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
    2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008

```

$$u = s_u(4.1) = 0.00010712$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_2

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010712$$

$$\mu = 3.4650 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\alpha(5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_c) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu = 0.01506636$$

$$\mu_e \text{ ((5.4c), TB DY)} = \alpha * \mu_{\min} * f_{ywe} / f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

where $\mu = \alpha * \mu_{pf} * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\mu_y = 0.07683125$$

$$\alpha_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_{pf} = 2t_f/b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$\mu_{f,f} = 0.015$$

$$\alpha_e \text{ ((5.4d), TB DY)} = (\alpha_e1 * A_{ext} + \alpha_e2 * A_{int}) / A_{sec} = 0.24250288$$

$$\alpha_e1 = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i2,1} = 462400.00$$

$$\alpha_e2 = \text{Max}(\alpha_e1, \alpha_e2) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i2,2} = 147456.00$$

$$\mu_{\min} * f_{ywe} = \text{Min}(\mu_{\min,x} * f_{ywe}, \mu_{\min,y} * f_{ywe}) = 3.07617$$

Expression ((5.4d), TB DY) for $\mu_{\min} * f_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\mu_{\min,x} * f_{ywe} = \mu_{\min,1} * f_{ywe1} + \mu_{\min,2} * f_{ywe2} = 3.07617$$

$$\mu_{\min,1} \text{ (external)} = (\alpha_{\min,1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$

$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 694.45$

with $Es1 = (Es, jacket * Asl, ten, jacket + Es, core * Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs, jacket * Asl, com, jacket + fs, core * Asl, com, core) / Asl, com = 694.45$

with $Es2 = (Es, jacket * Asl, com, jacket + Es, core * Asl, com, core) / Asl, com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$

$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv , ftv , fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 694.45$
 with $Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b * d) * (fs1 / fc) = 0.16759354$
 $2 = Asl_com / (b * d) * (fs2 / fc) = 0.16759354$
 $v = Asl_mid / (b * d) * (fsv / fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_ten / (b * d) * (fs1 / fc) = 0.21525776$
 $2 = Asl_com / (b * d) * (fs2 / fc) = 0.21525776$
 $v = Asl_mid / (b * d) * (fsv / fc) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs_y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $Vr = Min(Vr1, Vr2) = 642326.47$

Calculation of Shear Strength at edge 1, $Vr1 = 642326.47$

$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$
 $VColO = 642326.47$
 $knl = 1$ (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 $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 9.9249344E-012$
 $Vu = 5.2204734E-032$
 $d = 0.8 * h = 320.00$
 $Nu = 5976.808$
 $Ag = 160000.00$
 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:

$d = 160.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL \cdot t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 357.00
 $ffe ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 642326.47$
 $knl = 1$ (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)
 $M/Vd = 2.00$
 $\mu_u = 9.9249344E-012$
 $V_u = 5.2204734E-032$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

```

total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
fe = 0.004, from (11.6a), ACI 440
with fu = 0.01
From (11-11), ACI 440: Vs + Vf <= 488465.275
bw = 400.00
-----

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,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
#####
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13212
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lu,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1

```

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -4.7900285E-031$

EDGE -B-

Shear Force, $V_b = 4.7900285E-031$

BOTH EDGES

Axial Force, $F = -5976.808$

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, $V_e/V_r = 0.35962554$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$

with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 3.4650E+008$

$\mu_{1+} = 3.4650E+008$, 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

$\mu_{1-} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 3.4650E+008$

$\mu_{2+} = 3.4650E+008$, 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

$\mu_{2-} = 3.4650E+008$, 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 μ_{1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$\mu = 0.00010712$

$M_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$\alpha (5A.5, TBDY) = 0.002$

Final value of μ : $\mu^* = \text{shear_factor} * \max(\mu_c, \mu_{cc}) = 0.01506636$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_c = 0.01506636$

we ((5.4c), TBDY) $= a_s e^* \cdot \min(f_{ywe}/f_{ce} + \min(f_x, f_y)) = 0.08361288$

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)

$f_x = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{f,e} = 870.5244$

$f_y = 0.07683125$

$a_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{f,e} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_f = 0.015$

$a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$p_{sh,min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$

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)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$ps1$ (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h_1 = 400.00$

$ps2$ (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$ps1$ (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h_1 = 400.00$

$ps2$ (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

c = confinement factor = 1.13212

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$f_{y1} = 694.45$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo_{u,min} = lb/ld = 1.00$

$su_1 = 0.4 \cdot esu_1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_1_{nominal} = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 694.45$

with $Es1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

with $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.21525776$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.21525776$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu1-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00010712$$
$$\mu = 3.4650 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$
$$d = 357.00$$
$$d' = 43.00$$
$$v = 0.00126831$$
$$N = 5976.808$$
$$f_c = 33.00$$
$$c_o(5A.5, TBDY) = 0.002$$
$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$
$$\mu_e((5.4c), TBDY) = a_{se} * \mu_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

where $\mu = a_{se} * \mu_{sh, \min} * f_{ywe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.07683125$$
$$a_{se} = 0.57333333$$
$$b = 400.00$$
$$h = 400.00$$

From EC8 A.4.4.3(6), $\mu_{sh, \min} = 2t_f / b_w = 0.00508$

$$b_w = 400.00$$

effective stress from (A.35), $f_{f,e} = 870.5244$

$$\mu_y = 0.07683125$$
$$a_{se} = 0.57333333$$
$$b = 400.00$$
$$h = 400.00$$

From EC8 A.4.4.3(6), $\mu_{sh, \min} = 2t_f / b_w = 0.00508$

$$b_w = 400.00$$

effective stress from (A.35), $f_{f,e} = 870.5244$

$$R = 40.00$$

Effective FRP thickness, $t_f = N L^* t \cos(b_1) = 1.016$

$$f_{u,f} = 1055.00$$
$$E_f = 64828.00$$
$$u_{,f} = 0.015$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$
$$a_{se1} = 0.24250288$$

$$b_{o,1} = 340.00$$
$$h_{o,1} = 340.00$$
$$b_{i,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o,2} = 192.00$$
$$h_{o,2} = 192.00$$
$$b_{i,2} = 147456.00$$

$$\mu_{sh, \min} * f_{ywe} = \text{Min}(\mu_{sh, x} * f_{ywe}, \mu_{sh, y} * f_{ywe}) = 3.07617$$

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)

$$\mu_{sh, x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$
$$\mu_{sh1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$
$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

No stirrups, $n_{s,1} = 2.00$

$$h_1 = 400.00$$

$$\mu_{sh2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

No stirrups, $n_{s,2} = 2.00$

$$h_2 = 200.00$$

$$\mu_{sh, y} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5A5), \text{TB DY}), \text{TB DY: } cc = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TB DY)} = 0.032$$

From table 5A.1, TB DY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TB DY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_jacket \cdot Asl, \text{ten, jacket} + fs_core \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

$$\text{with } Es1 = (Es_jacket \cdot Asl, \text{ten, jacket} + Es_core \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TB DY)} = 0.032$$

From table 5A.1, TB DY: 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, TB DY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_jacket \cdot Asl, \text{com, jacket} + fs_core \cdot Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

$$\text{with } Es2 = (Es_jacket \cdot Asl, \text{com, jacket} + Es_core \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TB DY)} = 0.032$$

From table 5A.1, TB DY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TB DY

For calculation of esuv_nominal and yv, shv, ftv, fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TB DY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_jacket \cdot Asl, \text{mid, jacket} + fs_mid \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

$$\text{with } Esv = (Es_jacket \cdot Asl, \text{mid, jacket} + Es_mid \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.16759354$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.16759354$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05925959$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 37.35991$$

$$cc (5A.5, TBDY) = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.16321971$$

$$\mu_u = M_{Rc} (4.14) = 3.4650E+008$$

$$u = s_u (4.1) = 0.00010712$$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u2+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00010712$$

$$\mu_u = 3.4650E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, cc) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01506636$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$$

where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$

$f_u, f = 1055.00$

$E_f = 64828.00$

$u, f = 0.015$

$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$

$ase1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$ase2 = \max(ase1, ase2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$psh_{min} * F_{ywe} = \min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

Expression ((5.4d), TBDY) for $psh_{min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$

$ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$

$ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 400.00$

$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirrups, $ns_2 = 2.00$

$h2 = 200.00$

$A_{sec} = 160000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$

$c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lo_{min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal}((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and 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 $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.21525776$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MR_c (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

 Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

 Calculation of Mu_2 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$

```

d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.08361288
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
-----
fx = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ffe = 870.5244
-----
fy = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ffe = 870.5244
-----
R = 40.00
Effective FRP thickness, tf = NL*t*cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.07617
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 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00
-----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00
-----
Asec = 160000.00
s1 = 100.00

```

$s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$
 From ((5A.5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$
 with $Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.16759354$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.16759354$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.05925959$
 and confined core properties:
 $b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 37.35991$
 $cc (5A.5, \text{TBDY}) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.21525776$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.21525776$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $\mu (4.9) = 0.16321971$
 $\mu = M_{Rc} (4.14) = 3.4650E+008$
 $u = \mu (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 642326.47$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.3318154E-012$
 $V_u = 4.7900285E-031$
 $d = 0.8 * h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \min(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$
 $V_{ColO} = 642326.47$
 $knl = 1$ (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)
 $M/Vd = 2.00$
 $\mu_u = 1.3318154E-012$
 $V_u = 4.7900285E-031$
 $d = 0.8 * h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), ACI 440) = 188111.148$
 $f = 0.95$, 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, $t_{f1} = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

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, $\phi = 0.80$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d \geq 1$)

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

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, $M = 8.8887759E-011$

Shear Force, $V_2 = 4601.921$

Shear Force, $V_3 = 8.5161640E-014$

Axial Force, $F = -5974.966$

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 $u_R = 1.0$ $u = 0.05698684$
 $u = y + p = 0.05698684$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00653235$ ((4.29), Biskinis Phd))
 $M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $A_g = 160000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.966$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 1.0810813E-005$
with $f_y = 555.56$
 $d = 357.00$
 $y = 0.28026208$
 $A = 0.01881927$
 $B = 0.01057613$
with $p_t = 0.00680078$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.966$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.3130538E-005$
with $f_c' (12.3, (ACI 440)) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $rc = 40.00$
 $A_e / A_c = 0.56518315$
Effective FRP thickness, $t_f = N L * t * \cos(b_1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975148$
 $A = 0.01865339$
 $B = 0.01050082$
with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Adequate Lap Length: $I_b / I_d \geq 1$

- Calculation of p -

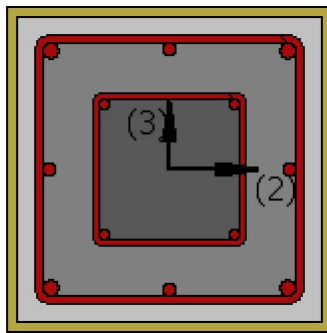
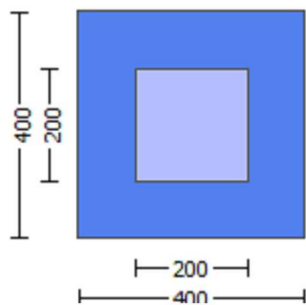
From table 10-8: $p = 0.05045449$
with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
 shear control ratio $V_{yE}/V_{ColOE} = 0.35962554$
 $d = d_{external} = 357.00$
 $s = s_{external} = 0.00$
 $t = s_1 + s_2 + 2*tf/bw*(f_{fe}/f_s) = 0.00680078$
 jacket: $s_1 = A_{v1}*h_1/(s_1*Ag) = 0.00392699$
 $A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction
 $h_1 = 400.00$
 $s_1 = 100.00$
 core: $s_2 = A_{v2}*h_2/(s_2*Ag) = 0.00050265$
 $A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction
 $h_2 = 200.00$
 $s_2 = 250.00$
 The term $2*tf/bw*(f_{fe}/f_s)$ is implemented to account for FRP contribution
 where $f = 2*tf/bw$ 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.
 $NUD = 5974.966$
 $Ag = 160000.00$
 $f_{cE} = (f_{c,jacket}*Area_{jacket} + f_{c,core}*Area_{core})/section_area = 33.00$
 $f_{yIE} = (f_{y,ext_Long_Reinf}*Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf}*Area_{int_Long_Reinf})/Area_{Tot_Long_Rein} = 555.56$
 $f_{yIE} = (f_{y,ext_Trans_Reinf}*Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf}*Area_{int_Trans_Reinf})/Area_{Tot_Trans_Rein} = 555.56$
 $\rho_l = Area_{Tot_Long_Rein}/(b*d) = 0.01874396$
 $b = 400.00$
 $d = 357.00$
 $f_{cE} = 33.00$

 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: Collapse Prevention (data interpolation between analysis steps 1 and 2)
 Analysis: Uniform +X
 Check: Shear capacity V_{Rd}
 Edge: End
 Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 0.80$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

External Height, $H = 400.00$

External Width, $W = 400.00$

Internal Height, $H = 200.00$

Internal Width, $W = 200.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $ef_u = 0.01$

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 = 1.6663953E-010
Shear Force, Va = -8.5161640E-014
EDGE -B-
Bending Moment, Mb = 8.8887759E-011
Shear Force, Vb = 8.5161640E-014
BOTH EDGES
Axial Force, F = -5974.966
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 = 585777.918
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 585777.918
VCol = 585777.918
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 $fc'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.8887759E-011
Vu = 8.5161640E-014
d = 0.8*h = 320.00
Nu = 5974.966
Ag = 160000.00
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) = 188111.148
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, $\theta = 45^\circ$ 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, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 425154.451$
 $b_w = 400.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 3.4905038E-023$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00653235$ ((4.29), Biskinis Phd))
 $M_y = 2.2575E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.7280E+013$
factor = 0.30
 $A_g = 160000.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 33.00$
 $N = 5974.966$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 5.7599E+013$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0810813E-005$
with $f_y = 555.56$
 $d = 357.00$
 $y = 0.28026208$
 $A = 0.01881927$
 $B = 0.01057613$
with $p_t = 0.00796398$
 $p_c = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.966$
 $b = 400.00$
 $\theta = 0.12044818$
 $y_{comp} = 2.3130538E-005$
with $f'_c (12.3, \text{ACI 440}) = 34.65043$
 $f_c = 33.00$
 $f_l = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $A_g = 160000.00$
From (12.9), ACI 440: $k_a = 0.56518315$
 $g = p_t + p_c + p_v = 0.01874396$
 $r_c = 40.00$
 $A_e / A_c = 0.56518315$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$
 $y = 0.27975148$
 $A = 0.01865339$

B = 0.01050082
with Es = 200000.00

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

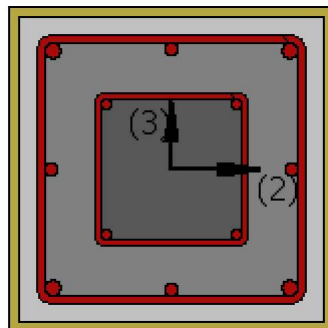
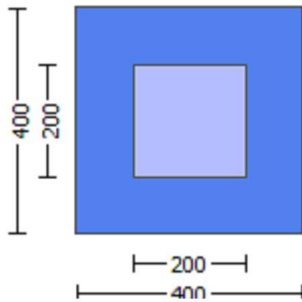
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\gamma = 0.80$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 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, $W = 400.00$
 Internal Height, $H = 200.00$
 Internal Width, $W = 200.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.13212
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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, $V_a = 5.2204734E-032$
 EDGE -B-
 Shear Force, $V_b = -5.2204734E-032$
 BOTH EDGES
 Axial Force, $F = -5976.808$
 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, $V_e/V_r = 0.35962554$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
 with
 $M_{pr1} = \max(M_{u1+}, M_{u1-}) = 3.4650E+008$
 $M_{u1+} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $M_{u1-} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.4650\text{E}+008$$

$M_{u2+} = 3.4650\text{E}+008$, 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

$M_{u2-} = 3.4650\text{E}+008$, 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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 0.00010712$$

$$M_u = 3.4650\text{E}+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\phi_{co} (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.01506636$$

$$\phi_{we} ((5.4c), \text{TB DY}) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.08361288$$

where $\phi_f = a_f * \phi_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\phi_{fy} = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00508$$

$$b_w = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(\theta_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f,f} = 0.015$$

$$a_{se} ((5.4d), \text{TB DY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$\phi_{sh, \min} * f_{ywe} = \text{Min}(\phi_{sh, x} * f_{ywe}, \phi_{sh, y} * f_{ywe}) = 3.07617$$

Expression ((5.4d), TB DY) 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)

$$\phi_{sh, x} * f_{ywe} = \phi_{sh1} * f_{ywe1} + \phi_{sh2} * f_{ywe2} = 3.07617$$

$$\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs_jacket \cdot Asl, ten, jacket + fs_core \cdot Asl, ten, core) / Asl, ten = 694.45$

with $Es1 = (Es_jacket \cdot Asl, ten, jacket + Es_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs_jacket \cdot Asl, com, jacket + fs_core \cdot Asl, com, core) / Asl, com = 694.45$

with $Es2 = (Es_jacket \cdot Asl, com, jacket + Es_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.16759354$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.16759354$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05925959$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 37.35991$

$cc \text{ (5A.5, TBDY)} = 0.00332119$

$c = \text{confinement factor} = 1.13212$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.21525776$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.21525776$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su \text{ (4.9)} = 0.16321971$

$Mu = MR_c \text{ (4.14)} = 3.4650E+008$

$u = su \text{ (4.1)} = 0.00010712$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010712$

$Mu = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$co \text{ (5A.5, TBDY)} = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01506636$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.01506636$

$w_e \text{ ((5.4c), TBDY)} = a_{se} \cdot sh_{min} \cdot fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.08361288$

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)

$fx = 0.07683125$

$af = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $ff_{e} = 870.5244$

$fy = 0.07683125$

$af = 0.57333333$

$b = 400.00$
 $h = 400.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $ff,e = 870.5244$

$R = 40.00$
 Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$
 $fu,f = 1055.00$
 $Ef = 64828.00$
 $u,f = 0.015$
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288$
 $ase1 = 0.24250288$
 $bo_1 = 340.00$
 $ho_1 = 340.00$
 $bi2_1 = 462400.00$
 $ase2 = Max(ase1,ase2) = 0.24250288$
 $bo_2 = 192.00$
 $ho_2 = 192.00$
 $bi2_2 = 147456.00$

$psh,min*Fywe = Min(psh,x*Fywe, psh,y*Fywe) = 3.07617$
 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)

$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617$
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617$
 $ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou,min = lb/ld = 1.00$

$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45$

```

with Es1 = (Esjacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fsjacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Esjacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Esjacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 0.00010712$$

$$\mu = 3.4650 \times 10^8$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\omega (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01506636$$

$$\omega_e ((5.4c), \text{TBDY}) = a_{se} * \frac{\min(f_{ywe}/f_{ce}, \min(f_x, f_y))}{f_c} = 0.08361288$$

where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$f_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(\beta_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f,f} = 0.015$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

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)

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$No \text{ stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_jacket \cdot Asl, \text{ten, jacket} + fs_core \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

$$\text{with } Es1 = (Es_jacket \cdot Asl, \text{ten, jacket} + Es_core \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_jacket \cdot Asl, \text{com, jacket} + fs_core \cdot Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

$$\text{with } Es2 = (Es_jacket \cdot Asl, \text{com, jacket} + Es_core \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_nominal = 0.08,$$

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv, ftv, fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_jacket \cdot Asl, \text{mid, jacket} + fs_mid \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

$$\text{with } Esv = (Es_jacket \cdot Asl, \text{mid, jacket} + Es_mid \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$$

$$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$$

$$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925959$$

and confined core properties:

$$b = 340.00$$

$d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21525776$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.21525776$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07611324$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.16321971$
 $Mu = MRc (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00010712$
 $Mu = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$
 $N = 5976.808$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01506636$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01506636$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$
 where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
 $b = 400.00$
 $h = 400.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00508$
 $bw = 400.00$
 effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$$

$$ase1 = 0.24250288$$

$$bo_1 = 340.00$$

$$ho_1 = 340.00$$

$$bi2_1 = 462400.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.24250288$$

$$bo_2 = 192.00$$

$$ho_2 = 192.00$$

$$bi2_2 = 147456.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$$

Expression ((5.4d), TBDY) for $psh_{min} * F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirrups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirrups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirrups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirrups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00332119$$

$$c = \text{confinement factor} = 1.13212$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$lo/lo_{min} = lb/l_d = 1.00$$

$$su1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$$

$$\text{with } Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$lo/lo_{min} = lb/l_{b,min} = 1.00$$

$$su2 = 0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $es_{2_nominal} = 0.08$,
 For calculation of $es_{2_nominal}$ and y_2 , sh_2 , ft_2 , fy_2 , it is considered
 characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.
 y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$
 with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou_{min} = lb/d = 1.00$
 $suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,
 considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $es_{uv_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered
 characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.
 y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.16759354$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.16759354$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 37.35991$
 $cc (5A.5, TBDY) = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.21525776$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.21525776$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.16321971$
 $\mu_u = MR_c (4.14) = 3.4650E+008$
 $u = su (4.1) = 0.00010712$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$

$V_{Col0} = 642326.47$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $fc'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9249344E-012$
 $\mu_v = 5.2204734E-032$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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 $\text{Col2} = 0.00$
 $s/d = 1.5625$
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 188111.148$
 $f = 0.95$, 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: $a_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, a_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 357.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $b_w = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col} ((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{Col0}$
 $V_{Col0} = 642326.47$
 $k_n l = 1$ (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: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 9.9249344E-012$
 $\mu_v = 5.2204734E-032$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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
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) = 188111.148
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 = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
fe = 0.004, from (11.6a), ACI 440
with fu = 0.01
From (11-11), ACI 440: Vs + Vf <= 488465.275
bw = 400.00

```

```

-----
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, = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
#####
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13212
Element Length, L = 3000.00
Secondary Member

```

Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 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, $V_a = -4.7900285E-031$
 EDGE -B-
 Shear Force, $V_b = 4.7900285E-031$
 BOTH EDGES
 Axial Force, $F = -5976.808$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -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, $V_e/V_r = 0.35962554$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 230997.004$
 with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.4650E+008$
 $M_{u1+} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $M_{u1-} = 3.4650E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.4650E+008$
 $M_{u2+} = 3.4650E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $M_{u2-} = 3.4650E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 0.00010712$
 $M_u = 3.4650E+008$

with full section properties:

$b = 400.00$
 $d = 357.00$
 $d' = 43.00$
 $v = 0.00126831$

```

N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.08361288
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
-----
fx = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ffe = 870.5244
-----
fy = 0.07683125
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ffe = 870.5244
-----
R = 40.00
Effective FRP thickness, tf = NL*t*cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.07617
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 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00
-----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirrups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirrups, ns_2 = 2.00
h2 = 200.00
-----
Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45

```

```

fywe2 = 694.45
fce = 33.00
From ((5A.5), TBDY), TBDY: cc = 0.00332119
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfinedsd full section - Steel rupture

```

satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$\mu_u(4.9) = 0.16321971$

$\mu_u = M_{Rc}(4.14) = 3.4650E+008$

$u = \mu_u(4.1) = 0.00010712$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u1} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00010712$

$\mu_u = 3.4650E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.00126831$

$N = 5976.808$

$f_c = 33.00$

$\alpha(5A.5, TBDY) = 0.002$

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.01506636$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_u = 0.01506636$

$\mu_{ue}((5.4c), TBDY) = \alpha * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.08361288$

where $f = \alpha * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.07683125$

$\alpha_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$f_y = 0.07683125$

$\alpha_f = 0.57333333$

$b = 400.00$

$h = 400.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00508$

$bw = 400.00$

effective stress from (A.35), $f_{fe} = 870.5244$

$R = 40.00$

Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f,f} = 0.015$

$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.24250288$

$\alpha_{se1} = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi2_1 = 462400.00$

$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi2_2 = 147456.00$

$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.07617$
 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)

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 400.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 200.00$

$Asec = 160000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
 $c = \text{confinement factor} = 1.13212$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$

$su1 = 0.4*esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou,min = lb/lb,min = 1.00$

$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45$

with $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$


```

fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

```

u = 0.00010712
Mu = 3.4650E+008

```

with full section properties:

```

b = 400.00
d = 357.00
d' = 43.00
v = 0.00126831
N = 5976.808
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01506636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01506636
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.08361288
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

fx = 0.07683125
af = 0.57333333

```

b = 400.00
h = 400.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$
bw = 400.00
effective stress from (A.35), $ff,e = 870.5244$

$f_y = 0.07683125$
 $a_f = 0.57333333$
b = 400.00
h = 400.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00508$
bw = 400.00
effective stress from (A.35), $ff,e = 870.5244$

R = 40.00
Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.24250288$
 $ase1 = 0.24250288$
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
 $ase2 = Max(ase1, ase2) = 0.24250288$
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
 $psh_{min}*F_{ywe} = Min(psh_x*F_{ywe}, psh_y*F_{ywe}) = 3.07617$
Expression ((5.4d), TBDY) for $psh_{min}*F_{ywe}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
h1 = 400.00
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
h2 = 200.00

$psh_y*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 3.07617$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/A_{sec} = 0.00392699$
 $Ash1 = Astir_1*ns_1 = 157.0796$
No stirrups, $ns_1 = 2.00$
h1 = 400.00
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/A_{sec} = 0.00050265$
 $Ash2 = Astir_2*ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
h2 = 200.00

$A_{sec} = 160000.00$
s1 = 100.00
s2 = 250.00
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
f_{ce} = 33.00
From ((5.A5), TBDY), TBDY: $cc = 0.00332119$
c = confinement factor = 1.13212
y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.16759354
2 = Asl,com/(b*d)*(fs2/fc) = 0.16759354
v = Asl,mid/(b*d)*(fsv/fc) = 0.05925959
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 37.35991
cc (5A.5, TBDY) = 0.00332119
c = confinement factor = 1.13212
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21525776
2 = Asl,com/(b*d)*(fs2/fc) = 0.21525776
v = Asl,mid/(b*d)*(fsv/fc) = 0.07611324
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vsy2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.16321971
Mu = MRc (4.14) = 3.4650E+008
u = su (4.1) = 0.00010712

```

Calculation of ratio lb/ld

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_2 -

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00010712$$

$$\mu = 3.4650 \times 10^{-8}$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.00126831$$

$$N = 5976.808$$

$$f_c = 33.00$$

$$\mu_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_0) = 0.01506636$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.01506636$$

$$\mu_{we} \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.08361288$$

where $\mu = a_f * \mu_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\mu_x = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A4.4.3(6), } \mu_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$\mu_y = 0.07683125$$

$$a_f = 0.57333333$$

$$b = 400.00$$

$$h = 400.00$$

$$\text{From EC8 A4.4.3(6), } \mu_f = 2t_f/bw = 0.00508$$

$$bw = 400.00$$

$$\text{effective stress from (A.35), } f_{fe} = 870.5244$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \cos(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$\mu_{f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i,2} = 147456.00$$

$$\mu_{sh,min} * f_{ywe} = \text{Min}(\mu_{sh,x} * f_{ywe}, \mu_{sh,y} * f_{ywe}) = 3.07617$$

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)

$$\mu_{sh,x} * f_{ywe} = \mu_{sh1} * f_{ywe1} + \mu_{sh2} * f_{ywe2} = 3.07617$$

$$\mu_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

No stirups, ns_2 = 2.00
h2 = 200.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00332119

c = confinement factor = 1.13212

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.16759354$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.16759354$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05925959$

and confined core properties:

$b = 340.00$
 $d = 327.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 37.35991$
 $c_{cc} \text{ (5A.5, TBDY)} = 0.00332119$
 $c = \text{confinement factor} = 1.13212$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.21525776$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.21525776$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07611324$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su \text{ (4.9)} = 0.16321971$
 $\mu_u = M_{Rc} \text{ (4.14)} = 3.4650E+008$
 $u = su \text{ (4.1)} = 0.00010712$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 642326.47$

Calculation of Shear Strength at edge 1, $V_{r1} = 642326.47$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{Col0}$

$V_{Col0} = 642326.47$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.3318154E-012$

$V_u = 4.7900285E-031$

$d = 0.8 \cdot h = 320.00$

$N_u = 5976.808$

$A_g = 160000.00$

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 $Col2 = 0.00$

$s/d = 1.5625$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 188111.148$
 $f = 0.95$, 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, $tf1 = NL \cdot t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 357.00
 $ffe((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 642326.47$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = knl \cdot V_{ColO}$
 $V_{ColO} = 642326.47$
 $knl = 1$ (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: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.3318154E-012$
 $\nu_u = 4.7900285E-031$
 $d = 0.8 \cdot h = 320.00$
 $N_u = 5976.808$
 $A_g = 160000.00$
 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 $Col2 = 0.00$
 $s/d = 1.5625$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 188111.148$
 $f = 0.95$, 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, $tf1 = NL \cdot t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 357.00
 $ffe((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 488465.275$
 $bw = 400.00$

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, $\gamma = 0.80$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 400.00$
External Width, $W = 400.00$
Internal Height, $H = 200.00$
Internal Width, $W = 200.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d \geq 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $\epsilon_{fu} = 0.01$
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, $M = 0.00652766$
Shear Force, $V_2 = 4601.921$
Shear Force, $V_3 = 8.5161640E-014$
Axial Force, $F = -5974.966$
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: $Asl_{ten} = 1137.257$
 -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 $u_R = 1.0^*$ $u = 0.05176096$
 $u = y + p = 0.05176096$

- Calculation of y -

$y = (My * Ls / 3) / E_{eff} = 0.00130647$ ((4.29), Biskinis Phd))
 $My = 2.2575E+008$
 $Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7280E+013$
 $factor = 0.30$
 $Ag = 160000.00$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 5974.966$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0810813E-005$
 with $f_y = 555.56$
 $d = 357.00$
 $y = 0.28026208$
 $A = 0.01881927$
 $B = 0.01057613$
 with $pt = 0.00680078$
 $pc = 0.00796398$
 $p_v = 0.00281599$
 $N = 5974.966$
 $b = 400.00$
 $" = 0.12044818$
 $y_{comp} = 2.3130538E-005$
 with $fc^* (12.3, (ACI 440)) = 34.65043$
 $fc = 33.00$
 $fl = 0.93147527$
 $b = 400.00$
 $h = 400.00$
 $Ag = 160000.00$
 From (12.9), ACI 440: $ka = 0.56518315$
 $g = pt + pc + p_v = 0.01874396$
 $rc = 40.00$
 $A_e / A_c = 0.56518315$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b1) = 1.016$
 effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 26999.444$

y = 0.27975148
A = 0.01865339
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.05045449

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1
shear control ratio VyE/VColOE = 0.35962554

d = d_external = 357.00

s = s_external = 0.00

t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00680078

jacket: s1 = Av1*h1/(s1*Ag) = 0.00392699

Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction

h1 = 400.00

s1 = 100.00

core: s2 = Av2*h2/(s2*Ag) = 0.00050265

Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction

h2 = 200.00

s2 = 250.00

The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution

where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation fs of jacket is used.

NUD = 5974.966

Ag = 160000.00

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}*Area_{ext_Trans_Reinf}+ f_{y_int_Trans_Reinf}*Area_{int_Trans_Reinf})/Area_{Tot_Trans_Rein} = 555.56

pl = Area_{Tot_Long_Rein}/(b*d) = 0.01874396

b = 400.00

d = 357.00

f_{cE} = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)