

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

- wall W1, Floor 1
- Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
- Analysis: Uniform +X
- Check: Shear capacity VRd
- Edge: Start
- Local Axis: (2)



- Start Of Calculation of Shear Capacity for element: wall W1 of floor 1
- At local axis: 2
- Integration Section: (a)
- Section Type: rcrws

Constant Properties

- Knowledge Factor, $\gamma = 1.00$
- Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
- Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
- Consequently:
- Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
- Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$
- Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 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

EDGE -A-
 Bending Moment, $M_a = 2.4645981E-011$
 Shear Force, $V_a = 1.7792573E-014$
 EDGE -B-
 Bending Moment, $M_b = 2.8343931E-011$
 Shear Force, $V_b = -1.7792573E-014$
 BOTH EDGES
 Axial Force, $F = -27506.85$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -Compression: $A_{slc} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 2368.761$
 -Compression: $A_{sl,com} = 2368.761$
 -Middle: $A_{sl,mid} = 1608.495$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 536498.781$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d = 536498.781$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 168485.214$
 $\mu_u/\mu_u - l_w/2 = 1260.184 > 0$
 = 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $\mu_u = 2.4645981E-011$
 $V_u = 1.7792573E-014$
 $N_u = 27506.85$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$
 $V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

Vs2 = 131946.891 is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

Vs3 = 0.00 is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 420.00$$

Vs3 has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.00$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 109599.773$$

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

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

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 $V_f(\theta, a)$, 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.

$$\text{orientation 1: } \theta = \theta_1 + 90^\circ = 90.00$$

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

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

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 208.00$$

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

$$E_f = 64828.00$$

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

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 3000.00$$

End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 2

wall W1, Floor 1

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

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 24.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

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Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $V_a = -1.0097420E-028$

EDGE -B-

Shear Force, $V_b = 1.0097420E-028$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 2865.133$

-Compression: $As_{c,com} = 2865.133$

-Middle: $As_{mid} = 0.00$

(According to 10.7.2.3 As_{mid} is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 1.97404$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 7.2241E+009$

$Mu_{1+} = 6.5646E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 7.2241E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 7.2241E+009$

$Mu_{2+} = 6.5646E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 7.2241E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 1.1622708E-005$

$M_u = 6.5646E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$

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

From (5.4b), TBDY: $\phi_u = 0.0035$

ϕ_{we} ((5.4c), TBDY) = $a s_e * \phi_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

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

$\phi_x = 0.00$

$a f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $\phi_f = 2 t_f / b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$\phi_y = 0.00$

$a f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $\phi_f = 2 t_f / b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase_3 = 0$ (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 656.25$
 $f_{ce} = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal((5.5), TBDY) = 0.032$
 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 $fs1 = fs = 656.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
 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 $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 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 $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.10597696$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.10597696$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.00$

and confined core properties:

$b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.14087258$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.14087258$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.00$

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

--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.06891069$
 $Mu = MRc (4.14) = 6.5646E+009$
 $u = su (4.1) = 1.1622708E-005$

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 1.1719585E-005$$

$$Mu = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.0035$$

$$w_e((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h_1} = 100.00$$

$$b_{o_1} = 190.00$$

$$h_{o_1} = 540.00$$

$$b_{i2_1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h_2} = 100.00$$

$$b_{o_2} = 190.00$$

$$h_{o_2} = 540.00$$

$$b_{i2_2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00

fywe = 656.25
fce = 24.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

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

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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

$\text{su} = 0.4 \cdot \text{esuv_nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $\text{esuv_nominal} = 0.08$,
 considering characteristic value $\text{fsv} = \text{fsv}/1.2$, from table 5.1, TBDY
 For calculation of esuv_nominal and yv , shv , ftv , fyv , it is considered
 characteristic value $\text{fsv} = \text{fsv}/1.2$, from table 5.1, TBDY.
 y1 , sh1 , ft1 , fy1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with $\text{fsv} = \text{fs} = 656.25$
 with $\text{Esv} = \text{Es} = 200000.00$
 $1 = \text{Asl,ten}/(\text{b} \cdot \text{d}) \cdot (\text{fs1}/\text{fc}) = 0.10597696$
 $2 = \text{Asl,com}/(\text{b} \cdot \text{d}) \cdot (\text{fs2}/\text{fc}) = 0.10597696$
 $v = \text{Asl,mid}/(\text{b} \cdot \text{d}) \cdot (\text{fsv}/\text{fc}) = 0.02277575$
 and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $\text{fcc} (5A.2, \text{TBDY}) = 24.08126$
 $\text{cc} (5A.5, \text{TBDY}) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = \text{Asl,ten}/(\text{b} \cdot \text{d}) \cdot (\text{fs1}/\text{fc}) = 0.14087258$
 $2 = \text{Asl,com}/(\text{b} \cdot \text{d}) \cdot (\text{fs2}/\text{fc}) = 0.14087258$
 $v = \text{Asl,mid}/(\text{b} \cdot \text{d}) \cdot (\text{fsv}/\text{fc}) = 0.03027525$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < \text{vs,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $\text{su} (4.9) = 0.07660732$
 $\text{Mu} = \text{MRc} (4.14) = 7.2241\text{E}+009$
 $u = \text{su} (4.1) = 1.1719585\text{E}-005$

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:

$u = 1.1622708\text{E}-005$

$\text{Mu} = 6.5646\text{E}+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$\text{fc} = 24.00$

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

Final value of cu : $\text{cu}^* = \text{shear_factor} \cdot \text{Max}(\text{cu}, \text{cc}) = 0.0035$

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

From (5.4b), TBDY: $\text{cu} = 0.0035$

$\text{we} ((5.4c), \text{TBDY}) = \text{ase} \cdot \text{sh,min} \cdot \text{fywe}/\text{fce} + \text{Min}(\text{fx}, \text{fy}) = 0.00$

where $f = \text{af} \cdot \text{pf} \cdot \text{ffe}/\text{fce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\text{fx} = 0.00$

$\text{af} = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A4.4.3(6), $\text{pf} = 2\text{tf}/\text{bw} = 0.008128$

$\text{bw} = 250.00$

effective stress from (A.35), $\text{ffe} = 748.2496$

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00067733
bw = 3000.00
effective stress from (A.35), ff,e = 953.7391

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*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25

```

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)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.06891069
Mu = MRc (4.14) = 6.5646E+009
u = su (4.1) = 1.1622708E-005

```

Calculation of ratio l_b/d

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

Calculation of μ_2

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

$\mu = 1.1719585E-005$

$\mu_2 = 7.2241E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

α (5A.5, TBDY) = 0.002

Final value of μ : $\mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_c) = 0.0035$

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

From (5.4b), TBDY: $\mu = 0.0035$

μ_e ((5.4c), TBDY) = $\alpha \cdot \text{sh}_{\min} \cdot f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$

Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(\theta_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$\mu_{f,f} = 0.015$

α_{se} ((5.4d), TBDY) = $(\alpha_{se1} \cdot A_{col1} + \alpha_{se2} \cdot A_{col2} + \alpha_{se3} \cdot A_{web})/A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi2_1 = 655400.00$

$\alpha_{se2} = 0.00$

$sh_2 = 100.00$

$bo_2 = 190.00$

$ho_2 = 540.00$

$bi2_2 = 655400.00$

$\alpha_{se3} = 0$ (grid does not provide confinement)

$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$

$p_{s1,x}$ (column 1) = $(A_{s1} \cdot h_1/s_1)/A_c = 0.00125664$

$h_1 = 600.00$

$As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 * ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 * h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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 $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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 $fs2 = fs = 656.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$
 $shv = 0.008$

```

ftv = 787.50
fyv = 656.25
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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
    2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
    v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
    c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
    v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83*fc'^{0.5}*h*d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$
 $\mu_u/V_u - l_w/2 = 0.00 \leq 0$
 = 1 (normal-weight concrete)
 $fc' = 24.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $\mu_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$

$s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 $\ln (11.3) \sin + \cos$ 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: $a = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L * t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526\text{E}+006$
 $b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397\text{E}+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 * f_c'^{0.5} * h * d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$
 $\mu_u / \mu_u - l_w / 2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $\mu_u = 6.1798626\text{E}-010$
 $\mu_u = 1.0097420\text{E}-028$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854\text{E}+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$
 $f = 0.95$, 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: $\theta_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = NL * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526\text{E}+006$
 $bw = 250.00$

 End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 3

 Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcrcws

Constant Properties

 Knowledge Factor, $K = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 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
 Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$
 #####
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00339
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
 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, $\text{NoDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -1.3805066E-030$

EDGE -B-

Shear Force, $V_b = 1.3805066E-030$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 2368.761$

-Compression: $As_{c,com} = 2368.761$

-Middle: $As_{mid} = 0.00$

(According to 10.7.2.3 As_{mid} is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21724146$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.3287E+008$

$\mu_{1+} = 2.5476E+008$, 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

$\mu_{1-} = 3.3287E+008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.3287E+008$

$\mu_{2+} = 2.5476E+008$, 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

$\mu_{2-} = 3.3287E+008$, 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:

$\mu = 0.00019036$

$\mu_u = 2.5476E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

α_0 (5A.5, TBDY) = 0.002

Final value of μ : $\mu^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.0035$

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

From (5.4b), TBDY: $\mu_u = 0.0035$

μ_c ((5.4c), TBDY) = $\alpha_{se} * \text{sh}_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A4.4.3(6), $p_f = 2t_f/b_w = 0.008128$

bw = 250.00
effective stress from (A.35), $f_{f,e} = 636.1644$

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $f_{f,e} = 944.3987$

R = 40.00
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = $(ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = $ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}$ (column 1) = $(As_1 \cdot h_1 / s_1) / A_c = 0.00125664$
h1 = 600.00
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, ns1 = 2.00
 $ps_{2,x}$ (column 2) = $(As_2 \cdot h_2 / s_2) / A_c = 0.00125664$
h2 = 600.00
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, ns2 = 2.00
 $ps_{3,x}$ (web) = $(As_3 \cdot h_3 / s_3) / A_c = 0.00188496$
h3 = 1800.00
 $As_3 = Astir_3 \cdot ns_3 = 0.00$
No stirups, ns3 = 2.00

psh,y = $ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}$ (column 1) = $(As_1 \cdot h_1 / s_1) / A_c = 0.0005236$
h1 = 250.00
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, ns1 = 2.00
 $ps_{2,y}$ (column 2) = $(As_2 \cdot h_2 / s_2) / A_c = 0.0005236$
h2 = 250.00
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, ns2 = 2.00
 $ps_{3,y}$ (web) = $(As_3 \cdot h_3 / s_3) / A_c = 0.00$
h3 = 250.00
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875

```

sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = fs = 525.00
    with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
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 = 525.00
    with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 525.00
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269

```

$$\begin{aligned} \mu_u &= M_{Rc} (4.14) = 2.5476E+008 \\ u &= s_u (4.1) = 0.00019036 \end{aligned}$$

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:
 $\mu_u = 0.00019626$
 $\mu_u = 3.3287E+008$

with full section properties:

$$\begin{aligned} b &= 3000.00 \\ d &= 208.00 \\ d' &= 42.00 \\ v &= 0.00275581 \\ N &= 27514.027 \\ f_c &= 16.00 \end{aligned}$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.0035$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h,1} = 100.00$$

$$b_{o,1} = 190.00$$

$$h_{o,1} = 540.00$$

$$b_{i2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h,2} = 100.00$$

$$b_{o,2} = 190.00$$

$$h_{o,2} = 540.00$$

$$b_{i2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 525.00$
 $fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$

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

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

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

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

with $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$

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

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

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

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

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

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

with $fs2 = fs = 525.00$

```

with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21612757
Mu = MRc (4.14) = 3.3287E+008
u = su (4.1) = 0.00019626

```

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 = 0.00019036
Mu = 2.5476E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.00

```

where $f = af \cdot pf \cdot ffe / fce$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$
 $af = 0.00$
 $b = 250.00$
 $h = 3000.00$
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.008128$
 $bw = 250.00$
effective stress from (A.35), $ffe = 636.1644$

$f_y = 0.00$
 $af = 0.00$
 $b = 3000.00$
 $h = 250.00$
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00067733$
 $bw = 3000.00$
effective stress from (A.35), $ffe = 944.3987$

$R = 40.00$
Effective FRP thickness, $tf = NL \cdot t \cdot \cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{col1} + ase2 \cdot A_{col2} + ase3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh_{min} = \min(psh_x, psh_y) = 0.0010472$

$psh_x = ps1_x + ps2_x + ps3_x = 0.00439823$
 $ps1_x$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2_x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3_x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
No stirups, $ns3 = 2.00$

$psh_y = ps1_y + ps2_y + ps3_y = 0.0010472$
 $ps1_y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2_y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3_y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
No stirups, $ns3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$


```

s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283

```

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)

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

--->
 $\mu (4.9) = 0.1918269$
 $\mu = M_{Rc} (4.14) = 2.5476E+008$
 $u = \mu (4.1) = 0.00019036$

Calculation of ratio I_b/I_d

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

Calculation of μ_2 -

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

$u = 0.00019626$
 $\mu = 3.3287E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $\alpha (5A.5, TBDY) = 0.002$
Final value of μ : $\mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_c) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu = 0.0035$
 $\mu_e ((5.4c), TBDY) = \alpha * \text{sh}_{min} * f_{ywe}/f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.00$
where $f = \alpha * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\mu_x = 0.00$
 $\alpha_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
From EC8 A4.4.3(6), $p_f = 2t_f/b_w = 0.008128$
 $b_w = 250.00$
effective stress from (A.35), $f_{fe} = 636.1644$

$\mu_y = 0.00$
 $\alpha_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
From EC8 A4.4.3(6), $p_f = 2t_f/b_w = 0.00067733$
 $b_w = 3000.00$
effective stress from (A.35), $f_{fe} = 944.3987$

$R = 40.00$
Effective FRP thickness, $t_f = N L * t * \cos(\beta_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{f,f} = 0.015$
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web})/A_{sec} = 0.00$
 $\alpha_{se1} = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi_{2,1} = 655400.00$
 $\alpha_{se2} = 0.00$

$sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \text{Min}(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 525.00$
 $fce = 16.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal$ ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 525.00$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = fs = 525.00$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0021875$
 $sh_v = 0.008$
 $ft_v = 630.00$
 $fy_v = 525.00$
 $suv = 0.032$
 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 $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.12455924$
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.12455924$
 $v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.08458134$
 and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.1008537$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21612757$
 $Mu = MR_c (4.14) = 3.3287E+008$
 $u = su (4.1) = 0.00019626$

 Calculation of ratio l_b/l_d

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

 Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 * f_c'^{0.5} * h * d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$
 $Mu/V_u - l_w/2 = 0.00 \leq 0$
 = 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$
 $d = 200.00$
 $lw = 250.00$
 $Mu = 5.1583838E-012$
 $Vu = 1.3805066E-030$
 $Nu = 27514.027$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 + Vs3 = 263893.783$
 $Vs1 = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $Av = 157079.633$
 $s = 100.00$
 $fy = 420.00$
 $Vs1$ has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $Vs2 = 131946.891$ is calculated for pseudo-Column 2, with:
 $d = 200.00$
 $Av = 157079.633$
 $s = 100.00$
 $fy = 420.00$
 $Vs2$ has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $Vs3 = 0.00$ is calculated for web, with:
 $d = 200.00$
 $Av = 0.00$
 $s = 200.00$
 $fy = 420.00$
 $Vs3$ has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.00$
 $Vf ((11-3)-(11.4), ACI 440) = 109599.773$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $Vf(,)$, is implemented for every different fiber orientation ai ,
 as well as for 2 crack directions, $a = 45^\circ$ and $a = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $a1 = b1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, 1)|, |Vf(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 208.00
 $ffe ((11-5), ACI 440) = 259.312$
 $Ef = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
 with $fu = 0.01$
 From (11-11), ACI 440: $Vs + Vf \leq 1.5943E+006$
 $bw = 3000.00$

 Calculation of Shear Strength at edge 2, $Vr2 = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $Vr2 = Vn < 0.83 * fc'^{0.5} * h * d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $Vc = 653502.805$
 $Mu / Vu - lw / 2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $fc' = 16.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $lw = 250.00$
 $Mu = 5.1583838E-012$
 $Vu = 1.3805066E-030$
 $Nu = 27514.027$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 + Vs3 = 263893.783$
 $Vs1 = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $Av = 157079.633$
 $s = 100.00$
 $fy = 420.00$
 $Vs1$ has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 131946.891 is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

Vs3 = 0.00 is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 420.00$$

Vs3 has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.00$$

$$V_f ((11-3)-(11.4), \text{ACI 440}) = 109599.773$$

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

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

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 a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

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

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

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

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 208.00$$

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

$$E_f = 64828.00$$

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

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 3000.00$$

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\phi = 1.00$

According to 10.7.2.3, ASCE 41-17, shear walls with

transverse reinforcement percentage, $\rho_n < 0.0015$

are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17

$$\rho_n = 0.0010472$$

with $\rho_n = \rho_{s1} + \rho_{s2} + \rho_{s3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 3

$$(\text{pseudo-col.1 } \rho_{s1} = A_{s1} * b1 / s1 = (A_{s1} * h1 / s1) / A_c = 0.0005236$$

$$h1 = 250.00$$

$$s1 = 100.00$$

$$\text{total area of hoops perpendicular to shear axis, } A_{s1} = 157.0796$$

$$(\text{pseudo-col.2 } \rho_{s2} = A_{s2} * b2 / s2 = (A_{s2} * h2 / s2) / A_c = 0.0005236$$

$$h2 = 250.00$$

$$s2 = 100.00$$

$$\text{total area of hoops perpendicular to shear axis, } A_{s2} = 157.0796$$

$$(\text{grid } \rho_{s3} = A_{s3} * b3 / s3 = (A_{s3} * h3 / s3) / A_c = 0.00$$

$$h3 = 250.00$$

$$s3 = 200.00$$

$$\text{total area of hoops perpendicular to shear axis, } A_{s3} = 0.00$$

$$\text{total section area, } A_c = 750000.00$$

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d > 1$)

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

Axial Force, $F = -27506.85$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{ten} = 2865.133$

-Compression: $As_{com} = 2865.133$

-Middle: $As_{mid} = 615.7522$

Mean Diameter of Tension Reinforcement, $Db_L = 17.33333$

Considering wall controlled by Shear (shear control ratio > 1),

interstorey drift provided values are calculated

Existing component: From table 7-7, ASCE 41_17: Final interstorey drift Capacity $u_R = \quad * u = 0.004$

from table 10-20: $u = 0.004$

with:

- Condition i (shear wall and wall segments)

- $(As - As') * f_y + P) / (t_w * l_w * f_c') = -0.21981836$

$As = 0.00$

$As' = 6346.017$

$f_y = 420.00$

$P = 27506.85$

$t_w = 250.00$

$l_w = 3000.00$

$f_c = 16.00$

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

wall W1, Floor 1

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

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $bi: 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = 9.7042E+007$
Shear Force, $V_a = -32343.002$
EDGE -B-
Bending Moment, $M_b = -2325.16$
Shear Force, $V_b = 32343.002$
BOTH EDGES
Axial Force, $F = -27506.85$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6346.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 2865.133$
-Compression: $As_{c,com} = 2865.133$
-Middle: $As_{mid} = 615.7522$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.33333$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = *V_n = 1.9920E+006$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83*fc'^{0.5}*h*d = 1.9920E+006$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 608675.665$
 $M_u/V_u - l_w/2 = 1500.388 > 0$
= 1 (normal-weight concrete)
 $fc' = 16.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $M_u = 9.7042E+007$
 $V_u = 32343.002$
 $N_u = 27506.85$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.1084E+006$

$V_{s1} = 316672.539$ is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s2} = 316672.539$ is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s3} = 475008.809$ is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 420.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$V_f((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$

$f = 0.95$, 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, $tf_1 = NL \cdot t / \text{NoDir} = 1.016$

$df_v = d$ (figure 11.2, ACI 440) = 2957.00

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

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 1.5943\text{E}+006$

$bw = 250.00$

End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 4

wall W1, Floor 1

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

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_r)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcwrs

Constant Properties

```

Knowledge Factor,  $\phi = 1.00$ 
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 24.00$ 
Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$ 
Concrete Elasticity,  $E_c = 23025.204$ 
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
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$ 
#####
Total Height,  $H_{tot} = 3000.00$ 
Edges Width,  $W_{edg} = 250.00$ 
Edges Height,  $H_{edg} = 600.00$ 
Web Width,  $W_{web} = 250.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.00339
Element Length,  $L = 3000.00$ 
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} \geq 1$ )
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,  $V_a = -1.0097420E-028$ 
EDGE -B-
Shear Force,  $V_b = 1.0097420E-028$ 
BOTH EDGES
Axial Force,  $F = -27514.027$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{sl,t} = 0.00$ 
-Compression:  $A_{sl,c} = 6346.017$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{sl,ten} = 2865.133$ 
-Compression:  $A_{sl,com} = 2865.133$ 
-Middle:  $A_{sl,mid} = 0.00$ 
(According to 10.7.2.3  $A_{sl,mid}$  is setted equal to zero)
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.97404$ 
Member Controlled by Shear ( $V_e/V_r > 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$ 
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 7.2241E+009$ 
 $M_{u1+} = 6.5646E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 7.2241E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment

```

direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 7.2241\text{E}+009$$

$M_{u2+} = 6.5646\text{E}+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 7.2241\text{E}+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$$\phi_u = 1.1622708\text{E}-005$$

$$M_u = 6.5646\text{E}+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

$$\text{Final value of } \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.0035$$

$$\phi_{we} ((5.4c), \text{TB DY}) = a_{se} * \phi_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$$

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

$$\phi_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$\phi_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se} ((5.4d), \text{TB DY}) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.0010472$$

$$\phi_{sh,x} = \phi_{s1,x} + \phi_{s2,x} + \phi_{s3,x} = 0.00439823$$

$$\phi_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$h1 = 600.00$
 $As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 * ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 * h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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 $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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 $fs2 = fs = 656.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$

```

shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
    2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
    v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
    c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
    v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.06891069
Mu = MRc (4.14) = 6.5646E+009
u = su (4.1) = 1.1622708E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 1.1719585E-005
Mu = 7.2241E+009

```

with full section properties:

```

b = 250.00
d = 2957.00
d' = 43.00
v = 0.00155078
N = 27514.027
fc = 24.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
    we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.00
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```

fx = 0.00
af = 0.00
b = 250.00
h = 3000.00
From EC8 A4.4.3(6), pf = $2t_f/bw = 0.008128$
bw = 250.00
effective stress from (A.35), ff,e = 748.2496

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), pf = $2t_f/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), ff,e = 953.7391

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) = $(ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = $\min(psh,x, psh,y) = 0.0010472$

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = $(As1*h1/s_1)/Ac = 0.00125664$
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = $(As2*h2/s_2)/Ac = 0.00125664$
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = $(As3*h3/s_3)/Ac = 0.00188496$
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = $(As1*h1/s_1)/Ac = 0.0005236$
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = $(As2*h2/s_2)/Ac = 0.0005236$
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = $(As3*h3/s_3)/Ac = 0.00$
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00

```

fywe = 656.25
fce = 24.00
From ((5A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfinedsd full section - Steel rupture

```


satisfies Eq. (4.3)

--->

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

--->

$s_u(4.9) = 0.07660732$

$M_u = M_{Rc}(4.14) = 7.2241E+009$

$u = s_u(4.1) = 1.1719585E-005$

Calculation of ratio I_b/I_d

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

Calculation of M_{u2+}

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

$u = 1.1622708E-005$

$M_u = 6.5646E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

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

Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha_c, \alpha_s) = 0.0035$

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

From (5.4b), TBDY: $\alpha_c = 0.0035$

$\alpha_s((5.4c), TBDY) = \alpha_{se} * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f,f} = 0.015$

$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_2 = 100.00$

$bo_2 = 190.00$

$ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \text{Min}(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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

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

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

From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 For calculation of $esuv_nominal$ 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 $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 656.25$
 with $Es = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.10597696$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.10597696$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.00$
 and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.14087258$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.14087258$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.00$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.06891069$
 $Mu = MRc (4.14) = 6.5646E+009$
 $u = su (4.1) = 1.1622708E-005$

 Calculation of ratio lb/ld

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

Calculation of $Mu2$ -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 1.1719585E-005$
 $Mu = 7.2241E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $fc = 24.00$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(\theta_1) = 1.016$$

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

$$E_f = 64828.00$$

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

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h_1} = 100.00$$

$$b_{o_1} = 190.00$$

$$h_{o_1} = 540.00$$

$$b_{i2_1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h_2} = 100.00$$

$$b_{o_2} = 190.00$$

$$h_{o_2} = 540.00$$

$$b_{i2_2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_{_1}) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_{_2}) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_{_3}) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_{_1}) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_{_2}) / A_c = 0.0005236$$

$$h_2 = 250.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,y} \text{ (web)} = (A_{s3} * h_3 / s_{_3}) / A_c = 0.00$$

$$h_3 = 250.00$$

$$As3 = Astir3 * ns3 = 157.0796$$

$$\text{No stirups, } ns3 = 0.00$$

$$Asec = 750000.00$$

$$s_1 = 100.00$$

$$s_2 = 100.00$$

$$s_3 = 200.00$$

$$fywe = 656.25$$

$$fce = 24.00$$

$$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 656.25$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 787.50$$

$$fy2 = 656.25$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 656.25$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

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

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

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.10597696$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.10597696$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.02277575$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

```

fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397E+006$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

```

From Table (11.5.4.6(d-e)), ACI 318-14: Vc = 799137.482
Mu/Vu-lw/2 = 0.00 <= 0
= 1 (normal-weight concrete)
fc' = 24.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
h = 250.00
d = 2400.00
lw = 3000.00
Mu = 6.1798626E-010
Vu = 1.0097420E-028
Nu = 27514.027
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 + Vs3 = 1.3854E+006
Vs1 = 395840.674 is calculated for pseudo-Column 1, with:
d = 480.00
Av = 157079.633
s = 100.00
fy = 525.00
Vs1 has been multiplied by 1 (s<d/2, according to ASCE 41-17,10.3.4)
Vs2 = 395840.674 is calculated for pseudo-Column 2, with:
d = 480.00
Av = 157079.633
s = 100.00
fy = 525.00
Vs2 has been multiplied by 1 (s<d/2, according to ASCE 41-17,10.3.4)
Vs3 = 593761.012 is calculated for web, with:
d = 1440.00
Av = 157079.633
s = 200.00
fy = 525.00
Vs3 has been multiplied by 1 (s<d/2, according to ASCE 41-17,10.3.4)
Vf ((11-3)-(11.4), ACI 440) = 1.5581E+006
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)sinα which is more a generalised expression,
where α 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, α = 45° and α = -45° to take into consideration the cyclic seismic loading.

```

orientation 1: $\theta_1 = \theta_{b1} + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_{fe} = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526E+006$
 $b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$
 $\mu_u / \mu_u - l_w / 2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $\mu_u = 6.1798626E-010$
 $\mu_u = 1.0097420E-028$
 $N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$

$V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:

$d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$

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

$V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:

$d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$

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

$V_{s3} = 593761.012$ is calculated for web, with:

$d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581E+006$

$f = 0.95$, for fully-wrapped sections

$w_f / s_f = 1$ (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: $\theta_1 = \theta_{b1} + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_{fe} = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526E+006$
 $b_w = 250.00$

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrcws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $V_a = -1.3805066E-030$

EDGE -B-

Shear Force, $V_b = 1.3805066E-030$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t, \text{ten}} = 2368.761$

-Compression: $As_{c, \text{com}} = 2368.761$

-Middle: $As_{\text{mid}} = 0.00$

(According to 10.7.2.3 As_{mid} is setted equal to zero)

Calculation of Shear Capacity ratio , $V_e/V_r = 0.21724146$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.3287\text{E}+008$

$\mu_{1+} = 2.5476\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{1-} = 3.3287\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.3287\text{E}+008$

$\mu_{2+} = 2.5476\text{E}+008$, 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

$\mu_{2-} = 3.3287\text{E}+008$, 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 μ_{1+}

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

$\phi_u = 0.00019036$

$\mu_u = 2.5476\text{E}+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

ϕ_{co} (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$

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

From (5.4b), TBDY: $\phi_{cu} = 0.0035$

ϕ_{we} ((5.4c), TBDY) = $a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$

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

 $\phi_{fx} = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $\phi_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $f_{fe} = 636.1644$

$\phi_{fy} = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $\phi_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35), $f_{fe} = 944.3987$

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f,f} = 0.015$

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi2_1 = 655400.00$

```

ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

```

```

-----
psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

```

```

-----
psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

```

```

-----
Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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 = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
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 = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269
Mu = MRc (4.14) = 2.5476E+008
u = su (4.1) = 0.00019036

```

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 = 0.00019626
Mu = 3.3287E+008

with full section properties:

b = 3000.00
d = 208.00
d' = 42.00

$v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $\phi_c (5A.5, TBDY) = 0.002$
 Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_c = 0.0035$
 $\phi_w ((5.4c), TBDY) = a_{se} * \phi_{w,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$
 where $\phi = a_f * \phi_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.00$
 $a_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A.4.4.3(6), $\phi_f = 2t_f / b_w = 0.008128$
 $b_w = 250.00$
 effective stress from (A.35), $f_{fe} = 636.1644$

$\phi_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A.4.4.3(6), $\phi_f = 2t_f / b_w = 0.00067733$
 $b_w = 3000.00$
 effective stress from (A.35), $f_{fe} = 944.3987$

$R = 40.00$
 Effective FRP thickness, $t_f = N L * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$
 $a_{se1} = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $a_{se2} = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $a_{se3} = 0$ (grid does not provide confinement)
 $\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.0010472$

$\phi_{sh,x} = \phi_{s1,x} + \phi_{s2,x} + \phi_{s3,x} = 0.00439823$
 $\phi_{s1,x} (\text{column 1}) = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$
 $h_1 = 600.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $\phi_{s2,x} (\text{column 2}) = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$
 $h_2 = 600.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$
 No stirups, $n_{s2} = 2.00$
 $\phi_{s3,x} (\text{web}) = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$
 $h_3 = 1800.00$
 $A_{s3} = A_{stir3} * n_{s3} = 0.00$
 No stirups, $n_{s3} = 2.00$

$\phi_{sh,y} = \phi_{s1,y} + \phi_{s2,y} + \phi_{s3,y} = 0.0010472$
 $\phi_{s1,y} (\text{column 1}) = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $\phi_{s2,y} (\text{column 2}) = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirups, ns2 = 2.00
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / A_c = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, ns3 = 0.00

 $A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fy_{we} = 525.00$
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$

$sh1 = 0.008$

$ft1 = 630.00$

$fy1 = 525.00$

$su1 = 0.032$

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

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

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

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 $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$

$sh2 = 0.008$

$ft2 = 630.00$

$fy2 = 525.00$

$su2 = 0.032$

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 $fs2 = fs = 525.00$

with $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

$suv = 0.032$

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 $fsv = fs = 525.00$

with $Esv = Es = 200000.00$

$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.12455924$

$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.12455924$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.08458134$

and confined core properties:

```

b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)

```

```

--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21612757
Mu = MRc (4.14) = 3.3287E+008
u = su (4.1) = 0.00019626

```

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 = 0.00019036
Mu = 2.5476E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+ Min( fx, fy) = 0.00
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```

```

fx = 0.00
af = 0.00
b = 250.00
h = 3000.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ffe = 636.1644

```

```

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00067733
bw = 3000.00
effective stress from (A.35), ffe = 944.3987

```

```

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*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00

ase1 = 0.00

sh_1 = 100.00

bo_1 = 190.00

ho_1 = 540.00

bi2_1 = 655400.00

ase2 = 0.00

sh_2 = 100.00

bo_2 = 190.00

ho_2 = 540.00

bi2_2 = 655400.00

ase3 = 0 (grid does not provide confinement)

psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823

ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664

h1 = 600.00

As1 = Astir1*ns1 = 157.0796

No stirups, ns1 = 2.00

ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664

h2 = 600.00

As2 = Astir2*ns2 = 157.0796

No stirups, ns2 = 2.00

ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496

h3 = 1800.00

As3 = Astir3*ns3 = 0.00

No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472

ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236

h1 = 250.00

As1 = Astir1*ns1 = 157.0796

No stirups, ns1 = 2.00

ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236

h2 = 250.00

As2 = Astir2*ns2 = 157.0796

No stirups, ns2 = 2.00

ps3,y (web) = (As3*h3/s_3)/Ac = 0.00

h3 = 250.00

As3 = Astir3*ns3 = 157.0796

No stirups, ns3 = 0.00

Asec = 750000.00

s_1 = 100.00

s_2 = 100.00

s_3 = 200.00

fywe = 525.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

y1 = 0.0021875

sh1 = 0.008

ft1 = 630.00

fy1 = 525.00

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 = 525.00

with Es1 = Es = 200000.00

```

y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
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 = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269
Mu = MRc (4.14) = 2.5476E+008
u = su (4.1) = 0.00019036

```

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 = 0.00019626
Mu = 3.3287E+008

with full section properties:

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$

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

From (5.4b), TBDY: $cu = 0.0035$

$we ((5.4c), TBDY) = ase * sh_{min} * fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.00$

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

$fx = 0.00$
 $af = 0.00$
b = 250.00
h = 3000.00
From EC8 A4.4.3(6), $pf = 2tf/bw = 0.008128$
bw = 250.00
effective stress from (A.35), $ff_e = 636.1644$

$fy = 0.00$
 $af = 0.00$
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $ff_e = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL * t * \cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase ((5.4d), TBDY) = (ase1 * A_{col1} + ase2 * A_{col2} + ase3 * A_{web}) / A_{sec} = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
 $psh_{min} = \text{Min}(psh_x, psh_y) = 0.0010472$

$psh_x = ps1_x + ps2_x + ps3_x = 0.00439823$
 $ps1_x (\text{column 1}) = (As1 * h1 / s_1) / A_c = 0.00125664$
h1 = 600.00
 $As1 = Astir1 * ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2_x (\text{column 2}) = (As2 * h2 / s_2) / A_c = 0.00125664$
h2 = 600.00
 $As2 = Astir2 * ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3_x (\text{web}) = (As3 * h3 / s_3) / A_c = 0.00188496$
h3 = 1800.00
 $As3 = Astir3 * ns3 = 0.00$
No stirups, ns3 = 2.00

$psh_y = ps1_y + ps2_y + ps3_y = 0.0010472$

ps1,y (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$

h1 = 250.00

As1 = Astir1*ns1 = 157.0796

No stirups, ns1 = 2.00

ps2,y (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$

h2 = 250.00

As2 = Astir2*ns2 = 157.0796

No stirups, ns2 = 2.00

ps3,y (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$

h3 = 250.00

As3 = Astir3*ns3 = 157.0796

No stirups, ns3 = 0.00

Asec = 750000.00

s_1 = 100.00

s_2 = 100.00

s_3 = 200.00

fywe = 525.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

y1 = 0.0021875

sh1 = 0.008

ft1 = 630.00

fy1 = 525.00

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 = 525.00

with Es1 = Es = 200000.00

y2 = 0.0021875

sh2 = 0.008

ft2 = 630.00

fy2 = 525.00

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 = 525.00

with Es2 = Es = 200000.00

yv = 0.0021875

shv = 0.008

ftv = 630.00

fyv = 525.00

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.

$y_1, sh_{1,ft1}, fy_1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = f_s = 525.00$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12455924$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12455924$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.08458134$

and confined core properties:

$b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 16.05417$
 $c_c \text{ (5A.5, TBDY)} = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.1008537$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su \text{ (4.9)} = 0.21612757$
 $\mu_u = M_{Rc} \text{ (4.14)} = 3.3287E+008$
 $u = su \text{ (4.1)} = 0.00019626$

Calculation of ratio lb/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$
 $\mu_u/V_u - l_w/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $\mu_u = 5.1583838E-012$
 $V_u = 1.3805066E-030$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$
 $V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_{s3} = 0.00$ is calculated for web, with:
 $d = 200.00$
 $A_v = 0.00$

$s = 200.00$
 $f_y = 420.00$
 V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.00$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 109599.773$
 $f = 0.95$, 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: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 208.00
 $f_{fe}((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.5943E+006$
 $b_w = 3000.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$
 $\mu_u / \mu_u - l_w / 2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $\mu_u = 5.1583838E-012$
 $\mu_u = 1.3805066E-030$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$
 $V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 0.00$ is calculated for web, with:
 $d = 200.00$
 $A_v = 0.00$
 $s = 200.00$
 $f_y = 420.00$
 V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.00$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 109599.773$
 $f = 0.95$, 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: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = NL \cdot t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 208.00
 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: $V_s + V_f \leq 1.5943E+006$
 $b_w = 3000.00$

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
 At local axis: 3
 Integration Section: (a)
 Section Type: rcrrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 According to 10.7.2.3, ASCE 41-17, shear walls with
 transverse reinforcement percentage, $n < 0.0015$
 are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17
 $n = 0.0010472$

with $n = ps1 + ps2 + ps3$, being the shear reinf. ratio in a plane perpendicular to the shear axis 2
 (pseudo-col.1 $ps1 = A_{s1} \cdot b1 / s1 = (A_{s1} \cdot h1 / s1) / A_c = 0.0005236$
 $h1 = 250.00$
 $s1 = 100.00$
 total area of hoops perpendicular to shear axis, $A_{s1} = 157.0796$
 (pseudo-col.2 $ps2 = A_{s2} \cdot b2 / s2 = (A_{s2} \cdot h2 / s2) / A_c = 0.0005236$
 $h2 = 250.00$
 $s2 = 100.00$
 total area of hoops perpendicular to shear axis, $A_{s2} = 157.0796$
 (grid $ps3 = A_{s3} \cdot b3 / s3 = (A_{s3} \cdot h3 / s3) / A_c = 0.00$
 $h3 = 250.00$
 $s3 = 200.00$
 total area of hoops perpendicular to shear axis, $A_{s3} = 0.00$
 total section area, $A_c = 750000.00$

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 Steel Elasticity, $E_s = 200000.00$
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b / l_d \geq 1$)
 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

Bending Moment, M = 2.4645981E-011
Shear Force, V2 = 1.7792573E-014
Shear Force, V3 = -32343.002
Axial Force, F = -27506.85
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6346.017
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2368.761
-Compression: Asl,com = 2368.761
-Middle: Asl,mid = 1608.495
Mean Diameter of Tension Reinforcement, DbL = 17.20

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_R = \phi$ $\phi = 0.0037905$
 $\phi = \phi_y + \phi_p = 0.0037905$

- Calculation of ϕ_y -

$\phi_y = (M_y \cdot I_p) / (EI)_{\text{Eff}} = 0.0017905$ ((10-5), ASCE 41-17))
 $M_y = 2.3485E+008$
 $(EI)_{\text{Eff}} = 0.35 \cdot E_c \cdot I$ (table 10-5)
 $E_c \cdot I = 8.9942E+013$
 $I_p = 0.5 \cdot d = 0.5 \cdot (0.8 \cdot h) = 240.00$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \text{Min}(\phi_{y,\text{ten}}, \phi_{y,\text{com}})$
 $\phi_{y,\text{ten}} = 1.3484638E-005$
with $f_y = 420.00$
 $d = 208.00$
 $\phi_y = 0.25128474$
 $A = 0.01027486$
 $B = 0.00621667$
with $p_t = 0.00379609$
 $p_c = 0.00379609$
 $p_v = 0.00257772$
 $N = 27506.85$
 $b = 3000.00$
 $\phi = 0.20192308$
 $\phi_{y,\text{comp}} = 2.4018281E-005$
with $f_c^* (12.3, (ACI 440)) = 16.002$
 $f_c = 16.00$
 $f_l = 0.17503396$
 $b = 3000.00$
 $h = 250.00$
 $A_g = 750000.00$
From (12.9), ACI 440: $k_a = 0.00364754$
 $g = p_t + p_c + p_v = 0.0101699$
 $r_c = 40.00$
 $A_e/A_c = 0.52524587$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$

effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$
 $E_c = 23025.204$
 $y = 0.25040216$
 $A = 0.00999371$
 $B = 0.00611172$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

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

- Calculation of p -

Considering wall controlled by flexure (shear control ratio ≤ 1),
from table 10-19: $p = 0.002$
with:

- Condition i (shear wall and wall segments)

- $(A_s - A_s') \cdot f_y + P / (t_w \cdot l_w \cdot f_c') = -0.21981836$

$A_s = 0.00$

$A_s' = 6346.017$

$f_y = 420.00$

$P = 27506.85$

$t_w = 3000.00$

$l_w = 250.00$

$f_c' = 16.00$

- $V / (t_w \cdot l_w \cdot f_c'^{0.5}) = 7.1423434E-020$, NOTE: units in lb & in

- Confined Boundary: No

Boundary hoops spacing does not exceed $8d_b$ ($s_1 < 8 \cdot d_b$ and $s_2 < 8 \cdot d_b$)

Boundary Trans. Reinf. does not exceed 50% of ACI 318 provision ($V_{w1} + V_{w2} > 0.50 \cdot (V - V_c - V_{w3})$)

With

Boundary Element 1:

$V_{w1} = 131946.891$

$s_1 = 100.00$

Boundary Element 2:

$V_{w2} = 131946.891$

$s_2 = 100.00$

Grid Shear Force, $V_{w3} = 0.00$

Concrete Shear Force, $V_c = 168485.214$

(The variables above have already been given in Shear control ratio calculation)

Mean diameter of all bars, $d_b = 17.33333$

Design Shear Force, $V = 1.7792573E-014$

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 5

wall W1, Floor 1

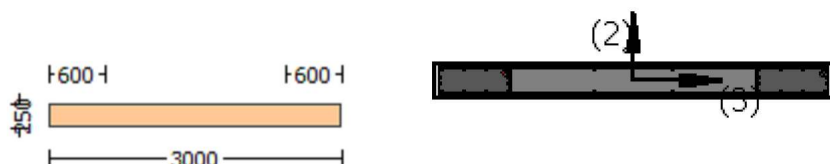
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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

EDGE -A-

Bending Moment, $M_a = 2.4645981\text{E-}011$

Shear Force, $V_a = 1.7792573\text{E-}014$

EDGE -B-

Bending Moment, $M_b = 2.8343931\text{E-}011$

Shear Force, $V_b = -1.7792573\text{E-}014$

BOTH EDGES

Axial Force, $F = -27506.85$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 2368.761$

-Compression: $As_{c,com} = 2368.761$

-Middle: $As_{mid} = 1608.495$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 529634.429$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d = 529634.429$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 161620.862$

$M_u/V_u - l_w/2 = 1468.02 > 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$M_u = 2.8343931\text{E-}011$

$V_u = 1.7792573\text{E-}014$

$N_u = 27506.85$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s3} = 0.00$ is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 420.00$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.00$

V_f ((11-3)-(11.4), ACI 440) = 109599.773

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (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: $\theta = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL \cdot t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 208.00
 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: $V_s + V_f \leq 1.5943E+006$
 $bw = 3000.00$

 End Of Calculation of Shear Capacity for element: wall W1 of floor 1
 At local axis: 2
 Integration Section: (b)

Calculation No. 6

wall W1, Floor 1
 Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
 Analysis: Uniform +X
 Check: Chord rotation capacity (ϕ)
 Edge: End
 Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcwrs

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 24.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
 Concrete Elasticity, $E_c = 23025.204$
 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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $V_a = -1.0097420E-028$

EDGE -B-

Shear Force, $V_b = 1.0097420E-028$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 2865.133$

-Compression: $A_{sl,com} = 2865.133$

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

(According to 10.7.2.3 $A_{sl,mid}$ is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 1.97404$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 7.2241E+009$

$\mu_{u1+} = 6.5646E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u1-} = 7.2241E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 7.2241E+009$

$\mu_{u2+} = 6.5646E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 7.2241E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu1+

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

$$\phi_u = 1.1622708E-005$$

$$M_u = 6.5646E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0035$$

$$\phi_{we} \text{ ((5.4c), TBDY)} = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$$

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

$$\phi_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$\phi_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_{pf} = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\phi_{psh, \min} = \text{Min}(\phi_{psh, x}, \phi_{psh, y}) = 0.0010472$$

$$\phi_{psh, x} = \phi_{ps1, x} + \phi_{ps2, x} + \phi_{ps3, x} = 0.00439823$$

$$\phi_{ps1, x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$\phi_{ps2, x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$ps3,x \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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

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

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

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

with $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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

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

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

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

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

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

with $fs2 = fs = 656.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$

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

$l_0/l_{ou,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv_nominal}$ and y_v , sh_v, ft_v, f_{yv} , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1 , sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = f_s = 656.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b * d) * (f_{s1}/f_c) = 0.10597696$
 $2 = A_{sl,com}/(b * d) * (f_{s2}/f_c) = 0.10597696$
 $v = A_{sl,mid}/(b * d) * (f_{sv}/f_c) = 0.00$

and confined core properties:

$b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b * d) * (f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b * d) * (f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b * d) * (f_{sv}/f_c) = 0.00$

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

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.06891069$
 $Mu = MR_c (4.14) = 6.5646E+009$
 $u = su (4.1) = 1.1622708E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 1.1719585E-005$
 $Mu = 7.2241E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$
 $w_e ((5.4c), TBDY) = a_s * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$
 where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$
 $a_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.008128$
 $bw = 250.00$
 effective stress from (A.35), $f_{fe} = 748.2496$

$f_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.00067733$
 $b_w = 3000.00$
 effective stress from (A.35), $f_{f,e} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web}) / A_{sec} = 0.00$
 $a_{se1} = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $a_{se2} = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $a_{se3} = 0$ (grid does not provide confinement)
 $p_{sh,min} = \min(p_{sh,x}, p_{sh,y}) = 0.0010472$

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$
 $p_{s1,x}$ (column 1) = $(A_{s1} \cdot h_1 / s_1) / A_c = 0.00125664$
 $h_1 = 600.00$
 $A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $p_{s2,x}$ (column 2) = $(A_{s2} \cdot h_2 / s_2) / A_c = 0.00125664$
 $h_2 = 600.00$
 $A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$
 No stirups, $n_{s2} = 2.00$
 $p_{s3,x}$ (web) = $(A_{s3} \cdot h_3 / s_3) / A_c = 0.00188496$
 $h_3 = 1800.00$
 $A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$
 No stirups, $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$
 $p_{s1,y}$ (column 1) = $(A_{s1} \cdot h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $p_{s2,y}$ (column 2) = $(A_{s2} \cdot h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$
 No stirups, $n_{s2} = 2.00$
 $p_{s3,y}$ (web) = $(A_{s3} \cdot h_3 / s_3) / A_c = 0.00$
 $h_3 = 250.00$
 $A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$
 No stirups, $n_{s3} = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 24.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$

```

fy1 = 656.25
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 = 656.25
    with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
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 = 656.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
    c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
    v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```


Calculation of ratio l_b/d

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

Calculation of Mu_{2+}

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

$$u = 1.1622708E-005$$

$$Mu = 6.5646E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

$$\phi_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_0) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0035$$

$$\phi_{we} \text{ ((5.4c), TBDY)} = a_{se} * \phi_{sh,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$$

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

$$\phi_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$\phi_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.0010472$$

$$\phi_{sh,x} = \phi_{s1,x} + \phi_{s2,x} + \phi_{s3,x} = 0.00439823$$

$$\phi_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$h1 = 600.00$
 $As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 * ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 * h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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 $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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 $fs2 = fs = 656.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$

```

shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
    2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
    v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
    c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
    v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.06891069
Mu = MRc (4.14) = 6.5646E+009
u = su (4.1) = 1.1622708E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

```

u = 1.1719585E-005
Mu = 7.2241E+009

```

with full section properties:

```

b = 250.00
d = 2957.00
d' = 43.00
v = 0.00155078
N = 27514.027
fc = 24.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
    we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.00
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```

fx = 0.00
af = 0.00
b = 250.00
h = 3000.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 748.2496

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00067733
bw = 3000.00
effective stress from (A.35), ff,e = 953.7391

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*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00

```

fywe = 656.25
fce = 24.00
From ((5A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfinedsd full section - Steel rupture

```

satisfies Eq. (4.3)

--->

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

--->

$\mu_u (4.9) = 0.07660732$

$\mu_u = M_{Rc} (4.14) = 7.2241E+009$

$u = \mu_u (4.1) = 1.1719585E-005$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c' \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u / V_u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 240.00$

$l_w = 3000.00$

$\mu_u = 6.1798626E-010$

$V_u = 1.0097420E-028$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$

$V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s3} = 593761.012$ is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 525.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

V_f ((11-3)-(11.4), ACI 440) = $1.5581E+006$

$f = 0.95$, 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 θ , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

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

$V_f = \min(|V_f(45, \theta)|, |V_f(-45, \theta)|)$, with:

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00

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: $V_s + V_f \leq 1.9526E+006$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u / V_u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 240.00$

$l_w = 3000.00$

$\mu_u = 6.1798626E-010$

$V_u = 1.0097420E-028$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$

$V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s3} = 593761.012$ is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 525.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)

V_f ((11-3)-(11.4), ACI 440) = $1.5581E+006$

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00

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: $V_s + V_f \leq 1.9526E+006$

$b_w = 250.00$

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrcws

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $V_a = -1.3805066E-030$

EDGE -B-

Shear Force, $V_b = 1.3805066E-030$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 2368.761$

-Compression: $A_{sl,com} = 2368.761$

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

(According to 10.7.2.3 $A_{sl,mid}$ is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21724146$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3287E+008$

Mu1+ = 2.5476E+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- = 3.3287E+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-) = 3.3287E+008

Mu2+ = 2.5476E+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- = 3.3287E+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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00019036$

Mu = 2.5476E+008

with full section properties:

b = 3000.00

d = 208.00

d' = 42.00

v = 0.00275581

N = 27514.027

fc = 16.00

co (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$

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

From (5.4b), TBDY: $\phi_u = 0.0035$

ϕ_{we} ((5.4c), TBDY) = $\text{ase} * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

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

 $\phi_x = 0.00$

$\text{af} = 0.00$

b = 250.00

h = 3000.00

From EC8 A.4.4.3(6), $\text{pf} = 2t_f / b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35), $f_{fe} = 636.1644$

 $\phi_y = 0.00$

$\text{af} = 0.00$

b = 3000.00

h = 250.00

From EC8 A.4.4.3(6), $\text{pf} = 2t_f / b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35), $f_{fe} = 944.3987$

R = 40.00

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

ase ((5.4d), TBDY) = $(\text{ase}_1 * A_{col1} + \text{ase}_2 * A_{col2} + \text{ase}_3 * A_{web}) / A_{sec} = 0.00$

$\text{ase}_1 = 0.00$

$\text{sh}_1 = 100.00$

$\text{bo}_1 = 190.00$

$\text{ho}_1 = 540.00$

$\text{bi}_2_1 = 655400.00$

$\text{ase}_2 = 0.00$

$\text{sh}_2 = 100.00$

$\text{bo}_2 = 190.00$

$\text{ho}_2 = 540.00$

$\text{bi}_2_2 = 655400.00$

$\text{ase}_3 = 0$ (grid does not provide confinement)

$\text{psh}_{\min} = \text{Min}(\text{psh}_x, \text{psh}_y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 525.00$
 $fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$

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

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

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

with $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$

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

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

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

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

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

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

```

with fs2 = fs = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269
Mu = MRc (4.14) = 2.5476E+008
u = su (4.1) = 0.00019036

```

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 = 0.00019626
Mu = 3.3287E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035

```

we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min(fx, fy) = 0.00
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

fx = 0.00
af = 0.00
b = 250.00
h = 3000.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 636.1644

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A.4.4.3(6), pf = 2tf/bw = 0.00067733
bw = 3000.00
effective stress from (A.35), ff,e = 944.3987

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*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00

$s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 525.00$
 $f_{ce} = 16.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $y_1 = 0.0021875$
 $sh_1 = 0.008$
 $ft_1 = 630.00$
 $fy_1 = 525.00$
 $su_1 = 0.032$
 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 $fsy_1 = fs_1/1.2$, 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 $fs_1 = fs = 525.00$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0021875$
 $sh_2 = 0.008$
 $ft_2 = 630.00$
 $fy_2 = 525.00$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lo_{u,min} = lb/lb_{,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_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 $fs_2 = fs = 525.00$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0021875$
 $sh_v = 0.008$
 $ft_v = 630.00$
 $fy_v = 525.00$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lo_{u,min} = lb/ld = 1.00$
 $suv = 0.4 * esuv_{,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{,nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = Asl_{,ten}/(b*d)*(fs_1/f_c) = 0.12455924$
 $2 = Asl_{,com}/(b*d)*(fs_2/f_c) = 0.12455924$
 $v = Asl_{,mid}/(b*d)*(fsv/f_c) = 0.08458134$
 and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl_{,ten}/(b*d)*(fs_1/f_c) = 0.14852283$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14852283$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1008537$$

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

---->

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

---->

$$s_u(4.9) = 0.21612757$$

$$\mu_u = M_{Rc}(4.14) = 3.3287E+008$$

$$u = s_u(4.1) = 0.00019626$$

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:

$$u = 0.00019036$$

$$\mu_u = 2.5476E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.0035$$

$$\mu_{ue}((5.4c), TBDY) = \alpha * \text{sh}_{min} * f_{ywe}/f_{ce} + \text{Min}(\mu_{fx}, \mu_{fy}) = 0.00$$

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

$$\mu_{fx} = 0.00$$

$$\mu_{af} = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\mu_{fy} = 0.00$$

$$\mu_{af} = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } \mu_{pf} = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web})/A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

```

ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

```

```

-----
psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

```

```

-----
psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

```

```

-----
Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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 = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
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 = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269
Mu = MRc (4.14) = 2.5476E+008
u = su (4.1) = 0.00019036

```

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 = 0.00019626
Mu = 3.3287E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00

```


$v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $\phi_0 (5A.5, TBDY) = 0.002$
 Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_c) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_{cu} = 0.0035$
 $\phi_{we} ((5.4c), TBDY) = \phi_{se} * \phi_{h,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$
 where $\phi_f = \phi_{af} * \phi_{pf} * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_{fx} = 0.00$
 $\phi_{af} = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/bw = 0.008128$
 $bw = 250.00$
 effective stress from (A.35), $f_{fe} = 636.1644$

$\phi_{fy} = 0.00$
 $\phi_{af} = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A.4.4.3(6), $\phi_{pf} = 2t_f/bw = 0.00067733$
 $bw = 3000.00$
 effective stress from (A.35), $f_{fe} = 944.3987$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\phi_{se} ((5.4d), TBDY) = (\phi_{se1} * A_{col1} + \phi_{se2} * A_{col2} + \phi_{se3} * A_{web}) / A_{sec} = 0.00$
 $\phi_{se1} = 0.00$
 $\phi_{sh,1} = 100.00$
 $\phi_{bo,1} = 190.00$
 $\phi_{ho,1} = 540.00$
 $\phi_{bi2,1} = 655400.00$
 $\phi_{se2} = 0.00$
 $\phi_{sh,2} = 100.00$
 $\phi_{bo,2} = 190.00$
 $\phi_{ho,2} = 540.00$
 $\phi_{bi2,2} = 655400.00$
 $\phi_{se3} = 0$ (grid does not provide confinement)
 $\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.0010472$

$\phi_{psh,x} = \phi_{ps1,x} + \phi_{ps2,x} + \phi_{ps3,x} = 0.00439823$
 $\phi_{ps1,x} (\text{column 1}) = (A_{s1} * h_1 / s_{_1}) / A_c = 0.00125664$
 $h_1 = 600.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $\phi_{ps2,x} (\text{column 2}) = (A_{s2} * h_2 / s_{_2}) / A_c = 0.00125664$
 $h_2 = 600.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$
 No stirups, $n_{s2} = 2.00$
 $\phi_{ps3,x} (\text{web}) = (A_{s3} * h_3 / s_{_3}) / A_c = 0.00188496$
 $h_3 = 1800.00$
 $A_{s3} = A_{stir3} * n_{s3} = 0.00$
 No stirups, $n_{s3} = 2.00$

$\phi_{psh,y} = \phi_{ps1,y} + \phi_{ps2,y} + \phi_{ps3,y} = 0.0010472$
 $\phi_{ps1,y} (\text{column 1}) = (A_{s1} * h_1 / s_{_1}) / A_c = 0.0005236$
 $h_1 = 250.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $\phi_{ps2,y} (\text{column 2}) = (A_{s2} * h_2 / s_{_2}) / A_c = 0.0005236$
 $h_2 = 250.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirups, ns2 = 2.00
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, ns3 = 0.00

 $Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 525.00$
 $fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$

$sh1 = 0.008$

$ft1 = 630.00$

$fy1 = 525.00$

$su1 = 0.032$

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 $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$

$sh2 = 0.008$

$ft2 = 630.00$

$fy2 = 525.00$

$su2 = 0.032$

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.

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

with $fs2 = fs = 525.00$

with $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

$suv = 0.032$

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.

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

with $fsv = fs = 525.00$

with $Esv = Es = 200000.00$

$1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.12455924$

$2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.12455924$

$v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.08458134$

and confined core properties:

$b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1008537$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21612757$
 $Mu = MR_c (4.14) = 3.3287E+008$
 $u = su (4.1) = 0.00019626$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83*f'_c*0.5*h*d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$
 $Mu/V_u - l_w/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f'_c = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $Mu = 5.1583838E-012$
 $V_u = 1.3805066E-030$
 $Nu = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$
 $V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$

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

$V_{s3} = 0.00$ is calculated for web, with:
 $d = 200.00$
 $A_v = 0.00$
 $s = 200.00$
 $f_y = 420.00$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.00$
 $V_f ((11-3)-(11.4), ACI 440) = 109599.773$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \alpha)|)$, with:
 total thickness per orientation, $tf1 = NL * t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 208.00
 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: $V_s + V_f \leq 1.5943E+006$
 $bw = 3000.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 * f_c' ^{0.5} * h * d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$
 $\mu_u / V_u - l_w / 2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c' ^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $\mu_u = 5.1583838E-012$
 $V_u = 1.3805066E-030$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$
 $V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:
 $d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 0.00$ is calculated for web, with:
 $d = 200.00$
 $A_v = 0.00$
 $s = 200.00$
 $f_y = 420.00$
 V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.00$
 V_f ((11-3)-(11.4), ACI 440) = 109599.773
 $f = 0.95$, for fully-wrapped sections
 $w_f / s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \alpha)|)$, with:
 total thickness per orientation, $tf1 = NL * t / \text{NoDir} = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 208.00
 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: $V_s + V_f \leq 1.5943E+006$

bw = 3000.00

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$
According to 10.7.2.3, ASCE 41-17, shear walls with
transverse reinforcement percentage, $n < 0.0015$
are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17
 $n = 0.0010472$

with $n = ps1 + ps2 + ps3$, being the shear reinf. ratio in a plane perpendicular to the shear axis 3
(pseudo-col.1 $ps1 = As1*b1/s1 = (As1*h1/s1) / Ac = 0.0005236$

$h1 = 250.00$

$s1 = 100.00$

total area of hoops perpendicular to shear axis, $As1 = 157.0796$

(pseudo-col.2 $ps2 = As2*b2/s2 = (As2*h2/s2) / Ac = 0.0005236$

$h2 = 250.00$

$s2 = 100.00$

total area of hoops perpendicular to shear axis, $As2 = 157.0796$

(grid $ps3 = As3*b3/s3 = (As3*h3/s3) / Ac = 0.00$

$h3 = 250.00$

$s3 = 200.00$

total area of hoops perpendicular to shear axis, $As3 = 0.00$

total section area, $Ac = 750000.00$

Consequently:

Existing material of Primary Member: Concrete Strength, $fc = fc_lower_bound = 16.00$

Existing material of Primary Member: Steel Strength, $fs = fs_lower_bound = 420.00$

Concrete Elasticity, $Ec = 23025.204$

Steel Elasticity, $Es = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $Wedg = 250.00$

Edges Height, $Hedg = 600.00$

Web Width, $Wweb = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $NoDir = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

Axial Force, $F = -27506.85$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6346.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{ten} = 2865.133$
-Compression: $As_{com} = 2865.133$
-Middle: $As_{mid} = 615.7522$
Mean Diameter of Tension Reinforcement, $Db_L = 17.33333$

Considering wall controlled by Shear (shear control ratio > 1),
interstorey drift provided values are calculated
Existing component: From table 7-7, ASCE 41_17: Final interstorey drift Capacity $u_R = u = 0.004$
from table 10-20: $u = 0.004$
with:
- Condition i (shear wall and wall segments)
- $(As - As') \cdot f_y + P / (t_w \cdot l_w \cdot f_c') = -0.21981836$
 $As = 0.00$
 $As' = 6346.017$
 $f_y = 420.00$
 $P = 27506.85$
 $t_w = 250.00$
 $l_w = 3000.00$
 $f_c = 16.00$

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 7

wall W1, Floor 1
Limit State: Operational Level (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: wall W1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcw

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $M_a = 9.7042E+007$

Shear Force, $V_a = -32343.002$

EDGE -B-

Bending Moment, $M_b = -2325.16$

Shear Force, $V_b = 32343.002$

BOTH EDGES

Axial Force, $F = -27506.85$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $Asl_{com} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl_{ten} = 2865.133$
 -Compression: $Asl_{com} = 2865.133$
 -Middle: $Asl_{mid} = 615.7522$
 Mean Diameter of Tension Reinforcement, $DbL_{ten} = 17.33333$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 1.9920E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d = 1.9920E+006$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653501.37$

$M_u/V_u - l_w/2 = -1499.928 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$M_u = 2325.16$

$V_u = 32343.002$

$N_u = 27506.85$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.1084E+006$

$V_{s1} = 316672.539$ is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s2} = 316672.539$ is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s3} = 475008.809$ is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 420.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

V_f ((11-3)-(11.4), ACI 440) = $1.5581E+006$

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00

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: $V_s + V_f \leq 1.5943E+006$

$b_w = 250.00$

End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 8

wall W1, Floor 1

Limit State: Operational Level (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: wall W1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcwls

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 24.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
 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, $V_a = -1.0097420E-028$
 EDGE -B-
 Shear Force, $V_b = 1.0097420E-028$
 BOTH EDGES
 Axial Force, $F = -27514.027$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 2865.133$
 -Compression: $A_{sl,com} = 2865.133$
 -Middle: $A_{sl,mid} = 0.00$
 (According to 10.7.2.3 $A_{sl,mid}$ is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 1.97404$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 7.2241E+009$
 $\mu_{u1+} = 6.5646E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 7.2241E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 7.2241E+009$
 $\mu_{u2+} = 6.5646E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 7.2241E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.1622708E-005$
 $M_u = 6.5646E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $\nu = 0.00155078$
 $N = 27514.027$

$$f_c = 24.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e ((5.4c), TBDY) = a_{se} * sh_{min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$$

$$h_2 = 250.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,y} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00$$

h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00

s_1 = 100.00

s_2 = 100.00

s_3 = 200.00

fywe = 656.25

fce = 24.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696

2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696

v = Asl,mid/(b*d)*(fsv/fc) = 0.00

and confined core properties:

b = 190.00

d = 2927.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

$su (4.9) = 0.06891069$
 $Mu = MRc (4.14) = 6.5646E+009$
 $u = su (4.1) = 1.1622708E-005$

Calculation of ratio l_b/l_d

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

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 1.1719585E-005$
 $Mu = 7.2241E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$
 where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$
 $a_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.008128$
 $bw = 250.00$
 effective stress from (A.35), $f_{f,e} = 748.2496$

$f_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
 $bw = 3000.00$
 effective stress from (A.35), $f_{f,e} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

```

ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

```

```

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

```

```

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

```

```

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00

```

```

fywe = 656.25
fce = 24.00

```

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

```

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
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 = 656.25

with Es1 = Es = 200000.00

```

y2 = 0.0025
sh2 = 0.008

```

```

ft2 = 787.50
fy2 = 656.25
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 = 656.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

u = 1.1622708E-005
Mu = 6.5646E+009

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.0035$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.0035$$

$$\alpha_e ((5.4c), \text{TB DY}) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.00$$

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

$$\alpha_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } \rho_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$\alpha_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } \rho_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$\alpha_{se} ((5.4d), \text{TB DY}) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$\alpha_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$psh_{\min} = \text{Min}(psh_x, psh_y) = 0.0010472$$

$$psh_x = ps1_x + ps2_x + ps3_x = 0.00439823$$

$$ps1_x \text{ (column 1)} = (As1 * h1 / s_1) / A_c = 0.00125664$$

$$h1 = 600.00$$

$$As1 = Astir1 * ns1 = 157.0796$$

$$\text{No stirups, } ns1 = 2.00$$

$$ps2_x \text{ (column 2)} = (As2 * h2 / s_2) / A_c = 0.00125664$$

$$h2 = 600.00$$

$$As2 = Astir2 * ns2 = 157.0796$$

$$\text{No stirups, } ns2 = 2.00$$

$$ps3_x \text{ (web)} = (As3 * h3 / s_3) / A_c = 0.00188496$$

$$h3 = 1800.00$$

$$As3 = Astir3 * ns3 = 0.00$$

$$\text{No stirups, } ns3 = 2.00$$

$$psh_y = ps1_y + ps2_y + ps3_y = 0.0010472$$

$$ps1_y \text{ (column 1)} = (As1 * h1 / s_1) / A_c = 0.0005236$$

$$h1 = 250.00$$

$As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

 $Asec = 750000.00$

$s_1 = 100.00$

$s_2 = 100.00$

$s_3 = 200.00$

$fywe = 656.25$

$fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$

$c = \text{confinement factor} = 1.00339$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 787.50$

$fy1 = 656.25$

$su1 = 0.032$

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 $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 787.50$

$fy2 = 656.25$

$su2 = 0.032$

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 $fs2 = fs = 656.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 787.50$

$fyv = 656.25$

$suv = 0.032$

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

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

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

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

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

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

with $fsv = fs = 656.25$

with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.10597696$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10597696$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.06891069$
 $\mu_u = M_{Rc} (4.14) = 6.5646E+009$
 $u = su (4.1) = 1.1622708E-005$

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:
 $u = 1.1719585E-005$
 $\mu_u = 7.2241E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $cc (5A.5, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, cc) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.0035$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$
where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$
 $a_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.008128$
 $b_w = 250.00$
effective stress from (A.35), $f_{f,e} = 748.2496$

$f_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.00067733$
 $b_w = 3000.00$
effective stress from (A.35), $f_{f,e} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase_3 = 0$ (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal((5.5), TBDY) = 0.032$
 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 $fs1 = fs = 656.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
 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 $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 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 $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.10597696$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.10597696$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.02277575$

and confined core properties:

$b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.14087258$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.14087258$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.03027525$

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

--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.07660732$
 $Mu = MRc (4.14) = 7.2241E+009$
 $u = su (4.1) = 1.1719585E-005$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u / u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 6.1798626E-010$

$V_u = 1.0097420E-028$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$

$V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s3} = 593761.012$ is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 525.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)

V_f ((11-3)-(11.4), ACI 440) = $1.5581E+006$

$f = 0.95$, 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 $V_f(\alpha)$, 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: $\alpha = b1 + 90^\circ = 90.00$

$V_f = \min(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00

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: $V_s + V_f \leq 1.9526E+006$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u / u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 2400.00$
 $lw = 3000.00$
 $Mu = 6.1798626E-010$
 $Vu = 1.0097420E-028$
 $Nu = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_f ((11-3)-(11.4), ACI 440) = 1.5581E+006$
 $f = 0.95$, 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, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_{fe} = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526E+006$
 $bw = 250.00$

 End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 3

 Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcrrws

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 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
 Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$
 #####

Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00339
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 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, $N_{oDir} = 1$
 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, $V_a = -1.3805066E-030$
 EDGE -B-
 Shear Force, $V_b = 1.3805066E-030$
 BOTH EDGES
 Axial Force, $F = -27514.027$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 2368.761$
 -Compression: $A_{sl,com} = 2368.761$
 -Middle: $A_{sl,mid} = 0.00$
 (According to 10.7.2.3 $A_{sl,mid}$ is setted equal to zero)

Calculation of Shear Capacity ratio , $V_e/V_r = 0.21724146$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3287E+008$
 $\mu_{u1+} = 2.5476E+008$, 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
 $\mu_{u1-} = 3.3287E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.3287E+008$
 $\mu_{u2+} = 2.5476E+008$, 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
 $\mu_{u2-} = 3.3287E+008$, 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:

$$\phi_u = 0.00019036$$

$$\mu = 2.5476 \times 10^8$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0035$$

$$\omega_e \text{ ((5.4c), TBDY)} = a_{se} * \frac{f_{ywe}}{f_{ce}} + \text{Min}(\phi_x, \phi_y) = 0.00$$

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

$$\phi_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\phi_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\rho_{sh,min} = \text{Min}(\rho_{sh,x}, \rho_{sh,y}) = 0.0010472$$

$$\rho_{sh,x} = \rho_{s1,x} + \rho_{s2,x} + \rho_{s3,x} = 0.00439823$$

$$\rho_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$\rho_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$\rho_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

Asec = 750000.00

$s_1 = 100.00$

$s_2 = 100.00$

$s_3 = 200.00$

$fywe = 525.00$

$fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$

$c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$

$sh1 = 0.008$

$ft1 = 630.00$

$fy1 = 525.00$

$su1 = 0.032$

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 $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$

$sh2 = 0.008$

$ft2 = 630.00$

$fy2 = 525.00$

$su2 = 0.032$

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 $fs2 = fs = 525.00$

with $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

$suv = 0.032$

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 $f_{sv} = f_{sv}/1.2$, 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 $f_{sv} = f_s = 525.00$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12455924$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12455924$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

and confined core properties:

$b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 16.05417$
 $cc \text{ (5A.5, TBDY)} = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su \text{ (4.9)} = 0.1918269$
 $Mu = MR_c \text{ (4.14)} = 2.5476E+008$
 $u = su \text{ (4.1)} = 0.00019036$

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:

$u = 0.00019626$
 $Mu = 3.3287E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $co \text{ (5A.5, TBDY)} = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$
 $w_e \text{ ((5.4c), TBDY)} = a_{se} \cdot sh_{,min} \cdot fy_{we}/f_{ce} + \text{Min}(fx, fy) = 0.00$
 where $f = af \cdot pf \cdot f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$fx = 0.00$
 $af = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.008128$
 $bw = 250.00$
 effective stress from (A.35), $ff_{,e} = 636.1644$

$fy = 0.00$
 $af = 0.00$
 $b = 3000.00$
 $h = 250.00$

From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00067733$
 $bw = 3000.00$
effective stress from (A.35), $ff,e = 944.3987$

$R = 40.00$
Effective FRP thickness, $tf = NL*t*\cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), TBDY) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1*h1/s_1)/Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1*ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2*h2/s_2)/Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2*ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3*h3/s_3)/Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3*ns3 = 0.00$
No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1*h1/s_1)/Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1*ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2*h2/s_2)/Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2*ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3*h3/s_3)/Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3*ns3 = 157.0796$
No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 525.00$
 $fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$

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

```

lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.21612757
Mu = MRc (4.14) = 3.3287E+008
u = su (4.1) = 0.00019626

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of μ_{2+}

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

$$\mu = 0.00019036$$

$$\mu = 2.5476 \times 10^{-8}$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.0035$$

$$\mu_{we} \text{ ((5.4c), TBDY)} = a_{se} * \mu_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\mu_x, \mu_y) = 0.00$$

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

$$\mu_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\mu_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \mu_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$\mu_{f} = 0.015$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = (a_{se1} A_{col1} + a_{se2} A_{col2} + a_{se3} A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$\mu_{sh,1} = 100.00$$

$$\mu_{bo,1} = 190.00$$

$$\mu_{ho,1} = 540.00$$

$$\mu_{bi,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$\mu_{sh,2} = 100.00$$

$$\mu_{bo,2} = 190.00$$

$$\mu_{ho,2} = 540.00$$

$$\mu_{bi,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.0010472$$

$$\mu_{psh,x} = \mu_{ps1,x} + \mu_{ps2,x} + \mu_{ps3,x} = 0.00439823$$

$$\mu_{ps1,x} \text{ (column 1)} = (A_{s1} h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$\mu_{ps2,x} \text{ (column 2)} = (A_{s2} h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 * ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 * h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 525.00$
 $fce = 16.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$
 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 $fs1 = fs = 525.00$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$
 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 $fs2 = fs = 525.00$
 with $Es2 = Es = 200000.00$
 $yv = 0.0021875$
 $shv = 0.008$
 $ftv = 630.00$
 $fyv = 525.00$
 $suv = 0.032$
 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 $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.12455924$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.12455924$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.00$
 and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.14852283$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.14852283$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.00$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.1918269$
 $Mu = MRc (4.14) = 2.5476E+008$
 $u = su (4.1) = 0.00019036$

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:

$u = 0.00019626$
 $Mu = 3.3287E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$
 $fc = 16.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$
 $we ((5.4c), TBDY) = ase * sh_{min} * fy_{we}/f_{ce} + \text{Min}(fx, fy) = 0.00$
 where $f = af * pf * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
 $fx = 0.00$
 $af = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.008128$

bw = 250.00
effective stress from (A.35), $f_{f,e} = 636.1644$

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $f_{f,e} = 944.3987$

R = 40.00
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = $(ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = $ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}$ (column 1) = $(As_1 \cdot h_1 / s_1) / A_c = 0.00125664$
h1 = 600.00
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, ns1 = 2.00
 $ps_{2,x}$ (column 2) = $(As_2 \cdot h_2 / s_2) / A_c = 0.00125664$
h2 = 600.00
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, ns2 = 2.00
 $ps_{3,x}$ (web) = $(As_3 \cdot h_3 / s_3) / A_c = 0.00188496$
h3 = 1800.00
 $As_3 = Astir_3 \cdot ns_3 = 0.00$
No stirups, ns3 = 2.00

psh,y = $ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}$ (column 1) = $(As_1 \cdot h_1 / s_1) / A_c = 0.0005236$
h1 = 250.00
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, ns1 = 2.00
 $ps_{2,y}$ (column 2) = $(As_2 \cdot h_2 / s_2) / A_c = 0.0005236$
h2 = 250.00
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, ns2 = 2.00
 $ps_{3,y}$ (web) = $(As_3 \cdot h_3 / s_3) / A_c = 0.00$
h3 = 250.00
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875


```

sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = fs = 525.00
    with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
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 = 525.00
    with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 525.00
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
    c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21612757

```

$$\begin{aligned} \mu &= MRC(4.14) = 3.3287E+008 \\ u &= su(4.1) = 0.00019626 \end{aligned}$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$$\mu_u / V_u - l_w / 2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$f_c' = 16.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 3000.00$$

$$d = 200.00$$

$$l_w = 250.00$$

$$\mu_u = 5.1583838E-012$$

$$V_u = 1.3805066E-030$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

$V_{s3} = 0.00$ is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 420.00$$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17, 10.3.4)

$$2(1-s/d) = 0.00$$

$$V_f ((11-3)-(11.4), \text{ ACI 440}) = 109599.773$$

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

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

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 a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

$$\text{orientation 1: } \theta_1 = b_1 + 90^\circ = 90.00$$

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

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

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 208.00$$

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

$$E_f = 64828.00$$

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

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 3000.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0215E+006$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$\mu_u / \mu_u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 5.1583838E-012$

$V_u = 1.3805066E-030$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s3} = 0.00$ is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 420.00$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.00$

V_f ((11-3)-(11.4), ACI 440) = 109599.773

$f = 0.95$, 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 $V_f(\alpha)$, 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: $\alpha = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 208.00

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: $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\phi = 1.00$
According to 10.7.2.3, ASCE 41-17, shear walls with
transverse reinforcement percentage, $\rho_n < 0.0015$
are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17
 $\rho_n = 0.0010472$

with $\rho_n = \rho_{s1} + \rho_{s2} + \rho_{s3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 2
(pseudo-col.1 $\rho_{s1} = A_{s1} \cdot b_1 / s_1 = (A_{s1} \cdot h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $s_1 = 100.00$
total area of hoops perpendicular to shear axis, $A_{s1} = 157.0796$
(pseudo-col.2 $\rho_{s2} = A_{s2} \cdot b_2 / s_2 = (A_{s2} \cdot h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $s_2 = 100.00$
total area of hoops perpendicular to shear axis, $A_{s2} = 157.0796$
(grid $\rho_{s3} = A_{s3} \cdot b_3 / s_3 = (A_{s3} \cdot h_3 / s_3) / A_c = 0.00$
 $h_3 = 250.00$
 $s_3 = 200.00$
total area of hoops perpendicular to shear axis, $A_{s3} = 0.00$
total section area, $A_c = 750000.00$

Consequently:
Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$
Concrete Elasticity, $E_c = 23025.204$
Steel Elasticity, $E_s = 200000.00$
Total Height, $H_{tot} = 3000.00$
Edges Width, $W_{edg} = 250.00$
Edges Height, $H_{edg} = 600.00$
Web Width, $W_{web} = 250.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b / l_d \geq 1$)
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, $M = 2.8343931E-011$
Shear Force, $V_2 = -1.7792573E-014$
Shear Force, $V_3 = 32343.002$
Axial Force, $F = -27506.85$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{slt} = 0.00$
-Compression: $A_{slc} = 6346.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 2368.761$
-Compression: $A_{sl,com} = 2368.761$
-Middle: $A_{sl,mid} = 1608.495$
Mean Diameter of Tension Reinforcement, $DbL = 17.20$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.0037905$

$$u = y + p = 0.0037905$$

- Calculation of y -

$$y = (M_y \cdot I_p) / (E I)_{\text{Eff}} = 0.0017905 \text{ ((10-5), ASCE 41-17)}$$

$$M_y = 2.3485 \text{E+008}$$

$$(E I)_{\text{Eff}} = 0.35 \cdot E_c \cdot I \text{ (table 10-5)}$$

$$E_c \cdot I = 8.9942 \text{E+013}$$

$$I_p = 0.5 \cdot d = 0.5 \cdot (0.8 \cdot h) = 240.00$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

$$y_{\text{ten}} = 1.3484638 \text{E-005}$$

$$\text{with } f_y = 420.00$$

$$d = 208.00$$

$$y = 0.25128474$$

$$A = 0.01027486$$

$$B = 0.00621667$$

$$\text{with } p_t = 0.00379609$$

$$p_c = 0.00379609$$

$$p_v = 0.00257772$$

$$N = 27506.85$$

$$b = 3000.00$$

$$" = 0.20192308$$

$$y_{\text{comp}} = 2.4018281 \text{E-005}$$

$$\text{with } f_c^* \text{ (12.3, (ACI 440))} = 16.002$$

$$f_c = 16.00$$

$$f_l = 0.17503396$$

$$b = 3000.00$$

$$h = 250.00$$

$$A_g = 750000.00$$

$$\text{From (12.9), ACI 440: } k_a = 0.00364754$$

$$g = p_t + p_c + p_v = 0.0101699$$

$$r_c = 40.00$$

$$A_e / A_c = 0.52524587$$

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

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

$$f_u = 0.01$$

$$E_f = 64828.00$$

$$E_c = 23025.204$$

$$y = 0.25040216$$

$$A = 0.00999371$$

$$B = 0.00611172$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio I_b / I_d

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

- Calculation of p -

Considering wall controlled by flexure (shear control ratio ≤ 1),
from table 10-19: $p = 0.002$

with:

- Condition i (shear wall and wall segments)

$$-(A_s - A_s') \cdot f_y + P / (t_w \cdot l_w \cdot f_c') = -0.21981836$$

$A_s = 0.00$
 $A_s' = 6346.017$
 $f_y = 420.00$
 $P = 27506.85$
 $t_w = 3000.00$
 $l_w = 250.00$
 $f_c = 16.00$
 - $V/(t_w \cdot l_w \cdot f_c^{0.5}) = 7.1423434E-020$, NOTE: units in lb & in
 - Confined Boundary: No
 Boundary hoops spacing does not exceed 8db ($s_1 < 8 \cdot db$ and $s_2 < 8 \cdot db$)
 Boundary Trans. Reinf. does not exceed 50% of ACI 318 provision ($V_{w1} + V_{w2} > 0.50 \cdot (V - V_c - V_{w3})$)
 With
 Boundary Element 1:
 $V_{w1} = 131946.891$
 $s_1 = 100.00$
 Boundary Element 2:
 $V_{w2} = 131946.891$
 $s_2 = 100.00$
 Grid Shear Force, $V_{w3} = 0.00$
 Concrete Shear Force, $V_c = 161620.862$
 (The variables above have already been given in Shear control ratio calculation)
 Mean diameter of all bars, $db = 17.33333$
 Design Shear Force, $V = 1.7792573E-014$

 End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
 At local axis: 3
 Integration Section: (b)

Calculation No. 9

wall W1, Floor 1
 Limit State: Life Safety (data interpolation between analysis steps 1 and 2)
 Analysis: Uniform +X
 Check: Shear capacity VR_d
 Edge: Start
 Local Axis: (2)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcwls

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $M_a = 1.8746810E-011$

Shear Force, $V_a = 1.4270893E-014$

EDGE -B-

Bending Moment, $M_b = 2.3754821E-011$

Shear Force, $V_b = -1.4270893E-014$

BOTH EDGES

Axial Force, $F = -27508.271$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $Asl_{com} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl_{ten} = 2368.761$
 -Compression: $Asl_{com} = 2368.761$
 -Middle: $Asl_{mid} = 1608.495$
 Mean Diameter of Tension Reinforcement, $DbL_{ten} = 17.20$

Existing component: From table 7-7, ASCE 41-17: Final Shear Capacity $V_R = V_n = 539417.148$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d = 539417.148$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 171403.581$
 $M_u/V_u - l_w/2 = 1188.64 > 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $M_u = 1.8746810E+011$
 $V_u = 1.4270893E+014$
 $N_u = 27508.271$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$
 $V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$d = 200.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$

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

$V_{s3} = 0.00$ is calculated for web, with:

$d = 200.00$
 $A_v = 0.00$
 $s = 200.00$
 $f_y = 420.00$

V_{s3} has been multiplied by 2(1-s/d) ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.00$

V_f ((11-3)-(11.4), ACI 440) = 109599.773

$f = 0.95$, for fully-wrapped sections

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

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

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

orientation 1: $a_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 208.00

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: $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

wall W1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcw

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 24.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 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, $V_a = -1.0097420E-028$
 EDGE -B-
 Shear Force, $V_b = 1.0097420E-028$
 BOTH EDGES
 Axial Force, $F = -27514.027$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 2865.133$
 -Compression: $As_{c,com} = 2865.133$
 -Middle: $As_{mid} = 0.00$
 (According to 10.7.2.3 As_{mid} is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 1.97404$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 7.2241E+009$
 $\mu_{u1+} = 6.5646E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 7.2241E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 7.2241E+009$
 $\mu_{u2+} = 6.5646E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $\mu_{u2-} = 7.2241E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 1.1622708E-005$
 $\mu_u = 6.5646E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$

$v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha = 0.0035$
 $\alpha_e ((5.4c), TBDY) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.00$
 where $\alpha = \alpha_f * \rho_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\alpha_x = 0.00$
 $\alpha_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A.4.4.3(6), $\rho_f = 2t_f/bw = 0.008128$
 $bw = 250.00$
 effective stress from (A.35), $f_{fe} = 748.2496$

$\alpha_y = 0.00$
 $\alpha_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A.4.4.3(6), $\rho_f = 2t_f/bw = 0.00067733$
 $bw = 3000.00$
 effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = N L^* t \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} A_{col1} + \alpha_{se2} A_{col2} + \alpha_{se3} A_{web}) / A_{sec} = 0.00$
 $\alpha_{se1} = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $\alpha_{se2} = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $\alpha_{se3} = 0$ (grid does not provide confinement)
 $\rho_{sh,\min} = \text{Min}(\rho_{sh,x}, \rho_{sh,y}) = 0.0010472$

$\rho_{sh,x} = \rho_{s1,x} + \rho_{s2,x} + \rho_{s3,x} = 0.00439823$
 $\rho_{s1,x}$ (column 1) = $(A_{s1} h_1 / s_1) / A_c = 0.00125664$
 $h_1 = 600.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $\rho_{s2,x}$ (column 2) = $(A_{s2} h_2 / s_2) / A_c = 0.00125664$
 $h_2 = 600.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$
 No stirups, $n_{s2} = 2.00$
 $\rho_{s3,x}$ (web) = $(A_{s3} h_3 / s_3) / A_c = 0.00188496$
 $h_3 = 1800.00$
 $A_{s3} = A_{stir3} * n_{s3} = 0.00$
 No stirups, $n_{s3} = 2.00$

$\rho_{sh,y} = \rho_{s1,y} + \rho_{s2,y} + \rho_{s3,y} = 0.0010472$
 $\rho_{s1,y}$ (column 1) = $(A_{s1} h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $\rho_{s2,y}$ (column 2) = $(A_{s2} h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirups, ns2 = 2.00
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / A_c = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, ns3 = 0.00

 $A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fy_{we} = 656.25$
 $f_{ce} = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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

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

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

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

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

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

with $fs2 = fs = 656.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$

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

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

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

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

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

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

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

with $fsv = fs = 656.25$

with $Esv = Es = 200000.00$

$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.10597696$

$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.10597696$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.00$

and confined core properties:

$b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.06891069$
 $Mu = MRc (4.14) = 6.5646E+009$
 $u = su (4.1) = 1.1622708E-005$

Calculation of ratio l_b/l_d

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

Calculation of $Mu1$ -

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

$u = 1.1719585E-005$
 $Mu = 7.2241E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$
 where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$
 $a_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.008128$
 $bw = 250.00$
 effective stress from (A.35), $f_{f,e} = 748.2496$

$f_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
 $bw = 3000.00$
 effective stress from (A.35), $f_{f,e} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$

u,f = 0.015

ase ((5.4d), TBDY) = (ase1*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00

ase1 = 0.00

sh_1 = 100.00

bo_1 = 190.00

ho_1 = 540.00

bi2_1 = 655400.00

ase2 = 0.00

sh_2 = 100.00

bo_2 = 190.00

ho_2 = 540.00

bi2_2 = 655400.00

ase3 = 0 (grid does not provide confinement)

psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823

ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664

h1 = 600.00

As1 = Astir1*ns1 = 157.0796

No stirups, ns1 = 2.00

ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664

h2 = 600.00

As2 = Astir2*ns2 = 157.0796

No stirups, ns2 = 2.00

ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496

h3 = 1800.00

As3 = Astir3*ns3 = 0.00

No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472

ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236

h1 = 250.00

As1 = Astir1*ns1 = 157.0796

No stirups, ns1 = 2.00

ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236

h2 = 250.00

As2 = Astir2*ns2 = 157.0796

No stirups, ns2 = 2.00

ps3,y (web) = (As3*h3/s_3)/Ac = 0.00

h3 = 250.00

As3 = Astir3*ns3 = 157.0796

No stirups, ns3 = 0.00

Asec = 750000.00

s_1 = 100.00

s_2 = 100.00

s_3 = 200.00

fywe = 656.25

fce = 24.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

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 = 656.25

with Es1 = Es = 200000.00

```

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

u = 1.1622708E-005
Mu = 6.5646E+009

with full section properties:

b = 250.00
d = 2957.00
d' = 43.00
v = 0.00155078
N = 27514.027
fc = 24.00
co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$

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

From (5.4b), TBDY: $cu = 0.0035$

w_e ((5.4c), TBDY) = $ase * sh_{min} * fy_{we} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$
 $af = 0.00$
b = 250.00
h = 3000.00
From EC8 A4.4.3(6), $pf = 2tf/bw = 0.008128$
bw = 250.00
effective stress from (A.35), $ff_e = 748.2496$

$f_y = 0.00$
 $af = 0.00$
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $ff_e = 953.7391$

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) = $(ase1 * A_{col1} + ase2 * A_{col2} + ase3 * A_{web}) / A_{sec} = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
 $psh_{min} = \text{Min}(psh_x, psh_y) = 0.0010472$

$psh_x = ps1_x + ps2_x + ps3_x = 0.00439823$
 $ps1_x$ (column 1) = $(As1 * h1 / s_1) / A_c = 0.00125664$
h1 = 600.00
 $As1 = Astir1 * ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2_x$ (column 2) = $(As2 * h2 / s_2) / A_c = 0.00125664$
h2 = 600.00
 $As2 = Astir2 * ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3_x$ (web) = $(As3 * h3 / s_3) / A_c = 0.00188496$
h3 = 1800.00
 $As3 = Astir3 * ns3 = 0.00$
No stirups, ns3 = 2.00

$psh_y = ps1_y + ps2_y + ps3_y = 0.0010472$

ps1,y (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$

h1 = 250.00

As1 = Astir1*ns1 = 157.0796

No stirups, ns1 = 2.00

ps2,y (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$

h2 = 250.00

As2 = Astir2*ns2 = 157.0796

No stirups, ns2 = 2.00

ps3,y (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$

h3 = 250.00

As3 = Astir3*ns3 = 157.0796

No stirups, ns3 = 0.00

Asec = 750000.00

s_1 = 100.00

s_2 = 100.00

s_3 = 200.00

fywe = 656.25

fce = 24.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

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.

$y_1, sh_{1,ft1}, fy_1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = f_s = 656.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.10597696$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.10597696$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

and confined core properties:

$b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 24.08126$
 $cc \text{ (5A.5, TBDY)} = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su \text{ (4.9)} = 0.06891069$
 $\mu_u = M_{Rc} \text{ (4.14)} = 6.5646E+009$
 $u = su \text{ (4.1)} = 1.1622708E-005$

Calculation of ratio lb/d

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

Calculation of μ_{u2} -

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

$u = 1.1719585E-005$
 $\mu_u = 7.2241E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $co \text{ (5A.5, TBDY)} = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$
 $w_e \text{ ((5.4c), TBDY)} = a_{se} \cdot sh_{,min} \cdot fy_{we}/f_{ce} + \text{Min}(fx, fy) = 0.00$
 where $f = a_f \cdot pf \cdot f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$fx = 0.00$
 $af = 0.00$
 $b = 250.00$
 $h = 3000.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.008128$
 $bw = 250.00$
 effective stress from (A.35), $ff_{,e} = 748.2496$

$fy = 0.00$
 $af = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00067733$

bw = 3000.00
effective stress from (A.35), $f_{f,e} = 953.7391$

R = 40.00
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase_3 = 0$ (grid does not provide confinement)
 $psh_{,min} = \min(psh_{,x}, psh_{,y}) = 0.0010472$

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / A_c = 0.00125664$
 $h_1 = 600.00$
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,x}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / A_c = 0.00125664$
 $h_2 = 600.00$
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,x}(\text{web}) = (As_3 \cdot h_3 / s_3) / A_c = 0.00188496$
 $h_3 = 1800.00$
 $As_3 = Astir_3 \cdot ns_3 = 0.00$
No stirups, $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,y}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,y}(\text{web}) = (As_3 \cdot h_3 / s_3) / A_c = 0.00$
 $h_3 = 250.00$
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$
No stirups, $ns_3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$f_{ywe} = 656.25$
 $f_{ce} = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $su_1 = 0.032$

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

```

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575

```

and confined core properties:

```

b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525

```

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

```

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 2.4397\text{E}+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397\text{E}+006$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u / V_u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 6.1798626\text{E}-010$

$V_u = 1.0097420\text{E}-028$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854\text{E}+006$

$V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 525.00$

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

$V_{s3} = 593761.012$ is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 525.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)

V_f ((11-3)-(11.4), ACI 440) = $1.5581\text{E}+006$

$f = 0.95$, 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, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00

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: $V_s + V_f \leq 1.9526\text{E}+006$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397\text{E}+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u / V_u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $lw = 3000.00$
 $\mu_u = 6.1798626E-010$
 $\nu_u = 1.0097420E-028$
 $\nu_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_f ((11-3)-(11.4), ACI 440) = 1.5581E+006$
 $f = 0.95$, 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, $t_{f1} = NL \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526E+006$
 $b_w = 250.00$

 End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 3

 Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcrrws

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 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

```

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 525.00$ 
#####
Total Height,  $H_{tot} = 3000.00$ 
Edges Width,  $W_{edg} = 250.00$ 
Edges Height,  $H_{edg} = 600.00$ 
Web Width,  $W_{web} = 250.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.00339
Element Length,  $L = 3000.00$ 
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} \geq 1$ )
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,  $V_a = -1.3805066E-030$ 
EDGE -B-
Shear Force,  $V_b = 1.3805066E-030$ 
BOTH EDGES
Axial Force,  $F = -27514.027$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{slt} = 0.00$ 
-Compression:  $A_{slc} = 6346.017$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{sl,ten} = 2368.761$ 
-Compression:  $A_{sl,com} = 2368.761$ 
-Middle:  $A_{sl,mid} = 0.00$ 
(According to 10.7.2.3  $A_{sl,mid}$  is setted equal to zero)
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.21724146$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$ 
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3287E+008$ 
 $\mu_{u1+} = 2.5476E+008$ , 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
 $\mu_{u1-} = 3.3287E+008$ , 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.3287E+008$ 
 $\mu_{u2+} = 2.5476E+008$ , 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
 $\mu_{u2-} = 3.3287E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
-----

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

```

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

$$\kappa_u = 0.00019036$$

$$M_u = 2.5476 \times 10^8$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$\nu = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \kappa_u: \kappa_u^* = \text{shear_factor} * \text{Max}(\kappa_u, \kappa_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \kappa_u = 0.0035$$

$$\omega_{se} ((5.4c), TBDY) = \alpha_{se} * \frac{\sigma_{se, \min} * f_{y, se}}{f_{c, se}} + \text{Min}(\frac{f_x}{f_c}, \frac{f_y}{f_c}) = 0.00$$

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

$$f_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$f_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{, f} = 0.015$$

$$\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$\alpha_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh, \min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.0010472$$

$$p_{sh, x} = p_{s1, x} + p_{s2, x} + p_{s3, x} = 0.00439823$$

$$p_{s1, x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2, x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3, x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339

y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
with fs1 = fs = 525.00
with Es1 = Es = 200000.00

y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
with fs2 = fs = 525.00
with Es2 = Es = 200000.00

yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

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

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

with $f_{sv} = f_s = 525.00$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12455924$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12455924$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

f_{cc} (5A.2, TBDY) = 16.05417

cc (5A.5, TBDY) = 0.00203386

c = confinement factor = 1.00339

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14852283$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14852283$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.1918269

$Mu = MR_c$ (4.14) = 2.5476E+008

$u = su$ (4.1) = 0.00019036

Calculation of ratio l_b/l_d

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

Calculation of Mu_1 -

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

$u = 0.00019626$

$Mu = 3.3287E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.0035$

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

From (5.4b), TBDY: $cu = 0.0035$

w_e ((5.4c), TBDY) = $ase \cdot sh_{min} \cdot fy_{we}/f_{ce} + \text{Min}(fx, fy) = 0.00$

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

$fx = 0.00$

$af = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A4.4.3(6), $pf = 2tf/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $ff_e = 636.1644$

$fy = 0.00$

$af = 0.00$

b = 3000.00
h = 250.00
From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $ff,e = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), TBDY) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
 $psh,min = Min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1*h1/s_1)/Ac = 0.00125664$
h1 = 600.00
 $As1 = Astir1*ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2,x$ (column 2) = $(As2*h2/s_2)/Ac = 0.00125664$
h2 = 600.00
 $As2 = Astir2*ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3,x$ (web) = $(As3*h3/s_3)/Ac = 0.00188496$
h3 = 1800.00
 $As3 = Astir3*ns3 = 0.00$
No stirups, ns3 = 2.00

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1*h1/s_1)/Ac = 0.0005236$
h1 = 250.00
 $As1 = Astir1*ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2,y$ (column 2) = $(As2*h2/s_2)/Ac = 0.0005236$
h2 = 250.00
 $As2 = Astir2*ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3,y$ (web) = $(As3*h3/s_3)/Ac = 0.00$
h3 = 250.00
 $As3 = Astir3*ns3 = 157.0796$
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = fs = 525.00$
with $Es_1 = Es = 200000.00$
 $y_2 = 0.0021875$
 $sh_2 = 0.008$
 $ft_2 = 630.00$
 $fy_2 = 525.00$
 $su_2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_2 = fs = 525.00$
with $Es_2 = Es = 200000.00$
 $y_v = 0.0021875$
 $sh_v = 0.008$
 $ft_v = 630.00$
 $fy_v = 525.00$
 $suv = 0.032$
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 $fsv = fs = 525.00$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.12455924$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.12455924$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.08458134$
and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.14852283$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.14852283$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.1008537$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.21612757$
 $Mu = MRc (4.14) = 3.3287E+008$
 $u = su (4.1) = 0.00019626$

Calculation of ratio l_b/l_d

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

Calculation of μ_{2+}

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

$$\mu = 0.00019036$$

$$\mu_u = 2.5476 \times 10^{-8}$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \mu_u: \mu_u = \text{shear_factor} * \text{Max}(\mu_c, \mu_o) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.0035$$

$$\mu_o \text{ ((5.4c), TBDY)} = a_{se} * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$

$s_1 = 100.00$

$s_2 = 100.00$

$s_3 = 200.00$

$fywe = 525.00$

$fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$

$c =$ confinement factor = 1.00339

$y1 = 0.0021875$

$sh1 = 0.008$

$ft1 = 630.00$

$fy1 = 525.00$

$su1 = 0.032$

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

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

$su1 = 0.4 \cdot esu1_nominal$ ((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 $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$

$sh2 = 0.008$

$ft2 = 630.00$

$fy2 = 525.00$

$su2 = 0.032$

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 $fs2 = fs = 525.00$

with $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

```

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*esuvnominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuvnominal = 0.08,
considering characteristic value fsv = fsv/1.2, from table 5.1, TBDY
For calculation of esuvnominal and yv, shv,ftv,fyv, it is considered
characteristic value fsv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 525.00
with Esv = Es = 200000.00
1 = Aslten/(b*d)*(fs1/fc) = 0.12455924
2 = Aslcom/(b*d)*(fs2/fc) = 0.12455924
v = Aslmid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Aslten/(b*d)*(fs1/fc) = 0.14852283
2 = Aslcom/(b*d)*(fs2/fc) = 0.14852283
v = Aslmid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269
Mu = MRc (4.14) = 2.5476E+008
u = su (4.1) = 0.00019036

```

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 = 0.00019626
Mu = 3.3287E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
we ((5.4c), TBDY) = ase* shmin*fywe/fce+Min( fx, fy) = 0.00
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
-----
fx = 0.00
af = 0.00
b = 250.00

```

h = 3000.00
From EC8 A4.4.3(6), $pf = 2tf/bw = 0.008128$
bw = 250.00
effective stress from (A.35), $ff,e = 636.1644$

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $ff,e = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
 $ase ((5.4d), TBDY) = (ase1*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = $(As1*h1/s_1)/Ac = 0.00125664$
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = $(As2*h2/s_2)/Ac = 0.00125664$
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = $(As3*h3/s_3)/Ac = 0.00188496$
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = $(As1*h1/s_1)/Ac = 0.0005236$
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = $(As2*h2/s_2)/Ac = 0.0005236$
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = $(As3*h3/s_3)/Ac = 0.00$
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386


```

c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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 = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
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 = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied

```

--->

$$\mu (4.9) = 0.21612757$$

$$\mu = M_{Rc} (4.14) = 3.3287E+008$$

$$u = \mu (4.1) = 0.00019626$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c' \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$$\mu_u / V_u - l_w / 2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$f_c' = 16.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 3000.00$$

$$d = 200.00$$

$$l_w = 250.00$$

$$\mu_u = 5.1583838E-012$$

$$V_u = 1.3805066E-030$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

$V_{s3} = 0.00$ is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 420.00$$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.00$$

$$V_f ((11-3)-(11.4), \text{ ACI 440}) = 109599.773$$

$f = 0.95$, 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.

$$\text{orientation 1: } a_1 = b_1 + 90^\circ = 90.00$$

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

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

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 208.00$$

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

$$E_f = 64828.00$$

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

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

bw = 3000.00

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0215E+006$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$
 $\mu_u / \mu - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 5.1583838E-012$

$V_u = 1.3805066E-030$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s3} = 0.00$ is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 420.00$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.00$

V_f ((11-3)-(11.4), ACI 440) = 109599.773

$f = 0.95$, 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 $V_f(\alpha)$, 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: $\alpha = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 208.00

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: $V_s + V_f \leq 1.5943E+006$

bw = 3000.00

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrrws

Constant Properties

Knowledge Factor, $\phi = 1.00$

According to 10.7.2.3, ASCE 41-17, shear walls with transverse reinforcement percentage, $\rho_n < 0.0015$

are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17
 $\rho_n = 0.0010472$

with $\rho_n = \rho_{s1} + \rho_{s2} + \rho_{s3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 3

(pseudo-col.1 $\rho_{s1} = A_{s1} \cdot b_1 / s_1 = (A_{s1} \cdot h_1 / s_1) / A_c = 0.0005236$

$h_1 = 250.00$

$s_1 = 100.00$

total area of hoops perpendicular to shear axis, $A_{s1} = 157.0796$

(pseudo-col.2 $\rho_{s2} = A_{s2} \cdot b_2 / s_2 = (A_{s2} \cdot h_2 / s_2) / A_c = 0.0005236$

$h_2 = 250.00$

$s_2 = 100.00$

total area of hoops perpendicular to shear axis, $A_{s2} = 157.0796$

(grid $\rho_{s3} = A_{s3} \cdot b_3 / s_3 = (A_{s3} \cdot h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$s_3 = 200.00$

total area of hoops perpendicular to shear axis, $A_{s3} = 0.00$

total section area, $A_c = 750000.00$

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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

Axial Force, $F = -27508.271$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 2865.133$

-Compression: $A_{st,com} = 2865.133$

-Middle: $A_{st,mid} = 615.7522$

Mean Diameter of Tension Reinforcement, $D_{bL} = 17.33333$

Considering wall controlled by Shear (shear control ratio > 1),
interstorey drift provided values are calculated
Existing component: From table 7-7, ASCE 41_17: Final interstorey drift Capacity $u_R = \gamma \cdot u = 0.015$
from table 10-20: $u = 0.015$

with:

- Condition i (shear wall and wall segments)

- $(A_s - A_s') \cdot f_y + P) / (t_w \cdot l_w \cdot f_c') = -0.21981824$

$A_s = 0.00$

$A_s' = 6346.017$

$f_y = 420.00$

$P = 27508.271$

$t_w = 250.00$

$l_w = 3000.00$

$f_c = 16.00$

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

wall W1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcwvs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 23025.204$

Steel Elasticity, $E_s = 200000.00$

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $M_a = 7.7834E+007$

Shear Force, $V_a = -25941.359$

EDGE -B-

Bending Moment, $M_b = -1864.942$

Shear Force, $V_b = 25941.359$

BOTH EDGES

Axial Force, $F = -27508.271$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 2865.133$

-Compression: $A_{sl,com} = 2865.133$

-Middle: $A_{sl,mid} = 615.7522$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.33333$

Existing component: From table 7-7, ASCE 41-17: Final Shear Capacity $V_R = \phi V_n = 1.9920E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c^{0.5} \cdot h \cdot d = 1.9920E+006$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 608676.119$

$\mu_u/V_u - l_w/2 = 1500.388 > 0$

$= 1$ (normal-weight concrete)

$f_c' = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

h = 250.00
d = 2400.00
lw = 3000.00
Mu = 7.7834E+007
Vu = 25941.359
Nu = 27508.271

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.1084E+006$

$V_{s1} = 316672.539$ is calculated for pseudo-Column 1, with:

d = 480.00
Av = 157079.633
s = 100.00
fy = 420.00

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

$V_{s2} = 316672.539$ is calculated for pseudo-Column 2, with:

d = 480.00
Av = 157079.633
s = 100.00
fy = 420.00

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

$V_{s3} = 475008.809$ is calculated for web, with:

d = 1440.00
Av = 157079.633
s = 200.00
fy = 420.00

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

V_f ((11-3)-(11.4), ACI 440) = 1.5581E+006

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, $t_{f1} = NL \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00

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: $V_s + V_f \leq 1.5943E+006$

bw = 250.00

End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

wall W1, Floor 1

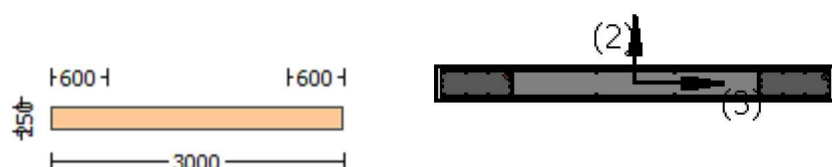
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_u)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 24.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.0097420E-028
EDGE -B-
Shear Force, Vb = 1.0097420E-028
BOTH EDGES
Axial Force, F = -27514.027
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6346.017
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2865.133
-Compression: Asl,com = 2865.133
-Middle: Asl,mid = 0.00
(According to 10.7.2.3 Asl,mid is setted equal to zero)

Calculation of Shear Capacity ratio , $V_e/V_r = 1.97404$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 7.2241E+009$
 $M_{u1+} = 6.5646E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 7.2241E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 7.2241E+009$
 $M_{u2+} = 6.5646E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $M_{u2-} = 7.2241E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.1622708E-005$
 $M_u = 6.5646E+009$

with full section properties:

b = 250.00
d = 2957.00
d' = 43.00
 $\nu = 0.00155078$
N = 27514.027
 $f_c = 24.00$
 $\phi_{co} (5A.5, \text{TBDY}) = 0.002$
Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_{cu} = 0.0035$
 $\phi_{we} ((5.4c), \text{TBDY}) = a_s e^* \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$
where $\phi_f = a_f * \phi_{pf} * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
 $\phi_{fx} = 0.00$
 $\phi_{af} = 0.00$

b = 250.00
h = 3000.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.008128$
bw = 250.00
effective stress from (A.35), $ff,e = 748.2496$

$f_y = 0.00$
 $a_f = 0.00$
b = 3000.00
h = 250.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $ff,e = 953.7391$

R = 40.00
Effective FRP thickness, $tf = NL*t*\cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), TBDY) = (ase1*A_{col1} + ase2*A_{col2} + ase3*A_{web})/A_{sec} = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1*h1/s_1)/Ac = 0.00125664$
h1 = 600.00
 $As1 = Astir1*ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2,x$ (column 2) = $(As2*h2/s_2)/Ac = 0.00125664$
h2 = 600.00
 $As2 = Astir2*ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3,x$ (web) = $(As3*h3/s_3)/Ac = 0.00188496$
h3 = 1800.00
 $As3 = Astir3*ns3 = 0.00$
No stirups, ns3 = 2.00

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1*h1/s_1)/Ac = 0.0005236$
h1 = 250.00
 $As1 = Astir1*ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2,y$ (column 2) = $(As2*h2/s_2)/Ac = 0.0005236$
h2 = 250.00
 $As2 = Astir2*ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3,y$ (web) = $(As3*h3/s_3)/Ac = 0.00$
h3 = 250.00
 $As3 = Astir3*ns3 = 157.0796$
No stirups, ns3 = 0.00

$A_{sec} = 750000.00$
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
 $f_{ywe} = 656.25$
fce = 24.00

From ((5.A.5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$
 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 $fs1 = fs = 656.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
 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 $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 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 $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.00$
 and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.00$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.06891069$$

$$M_u = M_{Rc}(4.14) = 6.5646E+009$$

$$u = s_u(4.1) = 1.1622708E-005$$

Calculation of ratio I_b/I_d

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

Calculation of M_{u1} -

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

$$\kappa_u = 1.1719585E-005$$

$$M_u = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

$$\text{Final value of } \kappa_u: \kappa_u^* = \text{shear_factor} * \text{Max}(\kappa_u, \kappa_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \kappa_u = 0.0035$$

$$\omega_{se}((5.4c), TBDY) = \alpha_{se} * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$f_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00

fywe = 656.25
fce = 24.00

From ((5.A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

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

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

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s2} = f_s = 656.25$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
 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
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = f_s = 656.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.10597696$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.10597696$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02277575$
 and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03027525$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.07660732$
 $Mu = MR_c (4.14) = 7.2241E+009$
 $u = su (4.1) = 1.1719585E-005$

 Calculation of ratio l_b/l_d

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

Calculation of Mu_{2+}

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

$u = 1.1622708E-005$
 $Mu = 6.5646E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.0035$

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

From (5.4b), TBDY: $c_u = 0.0035$

w_e ((5.4c), TBDY) = $a_{se} * sh_{min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$

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_{se} ((5.4d), TBDY) = $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi2_1 = 655400.00$

$a_{se2} = 0.00$

$sh_2 = 100.00$

$bo_2 = 190.00$

$ho_2 = 540.00$

$bi2_2 = 655400.00$

$a_{se3} = 0$ (grid does not provide confinement)

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$

$p_{s1,x}$ (column 1) = $(A_{s1} * h_1 / s_1) / A_c = 0.00125664$

$h_1 = 600.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirups, $n_{s1} = 2.00$

$p_{s2,x}$ (column 2) = $(A_{s2} * h_2 / s_2) / A_c = 0.00125664$

$h_2 = 600.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirups, $n_{s2} = 2.00$

$p_{s3,x}$ (web) = $(A_{s3} * h_3 / s_3) / A_c = 0.00188496$

$h_3 = 1800.00$

$A_{s3} = A_{stir3} * n_{s3} = 0.00$

No stirups, $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$

$p_{s1,y}$ (column 1) = $(A_{s1} * h_1 / s_1) / A_c = 0.0005236$

$h_1 = 250.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirups, $n_{s1} = 2.00$

$p_{s2,y}$ (column 2) = $(A_{s2} * h_2 / s_2) / A_c = 0.0005236$

$h_2 = 250.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirups, $n_{s2} = 2.00$

$p_{s3,y}$ (web) = $(A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3} * n_{s3} = 157.0796$

No stirups, $n_{s3} = 0.00$

```

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 656.25
fce = 24.00
From ((5.A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386

```


$c = \text{confinement factor} = 1.00339$

$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$

$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u(4.9) = 0.06891069$

$M_u = M_{Rc}(4.14) = 6.5646E+009$

$u = s_u(4.1) = 1.1622708E-005$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2} -

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

$u = 1.1719585E-005$

$M_u = 7.2241E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

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

Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.0035$

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

From (5.4b), TBDY: $\alpha = 0.0035$

$\alpha_{we}((5.4c), TBDY) = \alpha * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.00$

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

$\alpha_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$\alpha_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web})/A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_{,1} = 100.00$

$bo_{,1} = 190.00$

$ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \text{Min}(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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 $fs_2 = fs = 656.25$
with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
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 $fsv = fs = 656.25$
with $Es_v = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.10597696$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.10597696$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.02277575$
and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.14087258$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.14087258$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.03027525$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.07660732$
 $Mu = MRc (4.14) = 7.2241E+009$
 $u = su (4.1) = 1.1719585E-005$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397E+006$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 * f_c'^{0.5} * h * d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u/V_u-lw/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 240.00$
 $lw = 3000.00$
 $\mu_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 V_f ((11-3)-(11.4), ACI 440) = $1.5581E+006$
 $f = 0.95$, 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, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 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: $V_s + V_f \leq 1.9526E+006$
 $b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$
 $\mu_u/V_u-lw/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 240.00$
 $lw = 3000.00$
 $\mu_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$

$f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$
 $f = 0.95$, 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: $a = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526\text{E}+006$
 $b_w = 250.00$

 End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 3

 Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcrws

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 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
 Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$
 #####
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00339
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
 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, $V_a = -1.3805066E-030$
 EDGE -B-
 Shear Force, $V_b = 1.3805066E-030$
 BOTH EDGES
 Axial Force, $F = -27514.027$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 2368.761$
 -Compression: $A_{sl,com} = 2368.761$
 -Middle: $A_{sl,mid} = 0.00$
 (According to 10.7.2.3 $A_{sl,mid}$ is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21724146$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.3287E+008$
 $\mu_{u1+} = 2.5476E+008$, 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
 $\mu_{u1-} = 3.3287E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.3287E+008$
 $\mu_{u2+} = 2.5476E+008$, 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
 $\mu_{u2-} = 3.3287E+008$, 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 μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 0.00019036$
 $\mu_u = 2.5476E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$

$$f_c = 16.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e ((5.4c), TBDY) = a_{se} * sh_{min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$$

$$h_2 = 250.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,y} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00$$

h3 = 250.00
 As3 = Astir3*ns3 = 157.0796
 No stirups, ns3 = 0.00

Asec = 750000.00

s_1 = 100.00

s_2 = 100.00

s_3 = 200.00

fywe = 525.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

y1 = 0.0021875

sh1 = 0.008

ft1 = 630.00

fy1 = 525.00

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 = fs = 525.00

with Es1 = Es = 200000.00

y2 = 0.0021875

sh2 = 0.008

ft2 = 630.00

fy2 = 525.00

su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 525.00

with Es2 = Es = 200000.00

yv = 0.0021875

shv = 0.008

ftv = 630.00

fyv = 525.00

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

with fsv = fs = 525.00

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924

2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924

v = Asl,mid/(b*d)*(fsv/fc) = 0.00

and confined core properties:

b = 2940.00

d = 178.00


```

d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269
Mu = MRc (4.14) = 2.5476E+008
u = su (4.1) = 0.00019036

```

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 = 0.00019626
Mu = 3.3287E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.00
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```

```

fx = 0.00
af = 0.00
b = 250.00
h = 3000.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 636.1644

```

```

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00067733
bw = 3000.00
effective stress from (A.35), ff,e = 944.3987

```

```

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*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00

```

```

ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

```

```

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

```

```

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

```

```

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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 = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008

```

```

ft2 = 630.00
fy2 = 525.00
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 = 525.00
    with Es2 = Es = 200000.00
    yv = 0.0021875
    shv = 0.008
    ftv = 630.00
    fyv = 525.00
    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 = 525.00
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
    2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.21612757
Mu = MRc (4.14) = 3.3287E+008
u = su (4.1) = 0.00019626

```

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 = 0.00019036
Mu = 2.5476E+008

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.0035$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.0035$$

$$\alpha_e ((5.4c), \text{TB DY}) = \alpha_e * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.00$$

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

$$\alpha_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } \rho_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\alpha_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } \rho_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$\alpha_e ((5.4d), \text{TB DY}) = (\alpha_{e1} * A_{col1} + \alpha_{e2} * A_{col2} + \alpha_{e3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{e1} = 0.00$$

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

$$\text{bo}_1 = 190.00$$

$$\text{ho}_1 = 540.00$$

$$\text{bi2}_1 = 655400.00$$

$$\alpha_{e2} = 0.00$$

$$\text{sh}_2 = 100.00$$

$$\text{bo}_2 = 190.00$$

$$\text{ho}_2 = 540.00$$

$$\text{bi2}_2 = 655400.00$$

$$\alpha_{e3} = 0 \text{ (grid does not provide confinement)}$$

$$\text{psh}_{\min} = \text{Min}(\text{psh}_x, \text{psh}_y) = 0.0010472$$

$$\text{psh}_x = \text{ps1}_x + \text{ps2}_x + \text{ps3}_x = 0.00439823$$

$$\text{ps1}_x \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$\text{ps2}_x \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$\text{ps3}_x \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$\text{psh}_y = \text{ps1}_y + \text{ps2}_y + \text{ps3}_y = 0.0010472$$

$$\text{ps1}_y \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

 $Asec = 750000.00$

$s_1 = 100.00$

$s_2 = 100.00$

$s_3 = 200.00$

$fywe = 525.00$

$fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$

$c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$

$sh1 = 0.008$

$ft1 = 630.00$

$fy1 = 525.00$

$su1 = 0.032$

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 $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$

$sh2 = 0.008$

$ft2 = 630.00$

$fy2 = 525.00$

$su2 = 0.032$

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 $fs2 = fs = 525.00$

with $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

$suv = 0.032$

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

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

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

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

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

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

with $fsv = fs = 525.00$

with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.12455924$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12455924$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.1918269$
 $Mu = MR_c (4.14) = 2.5476E+008$
 $u = su (4.1) = 0.00019036$

Calculation of ratio l_b/d

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

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00019626$
 $Mu = 3.3287E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.0035$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$
where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

 $f_x = 0.00$
 $a_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.008128$
 $bw = 250.00$
effective stress from (A.35), $f_{f,e} = 636.1644$

 $f_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
 $bw = 3000.00$
effective stress from (A.35), $f_{f,e} = 944.3987$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase((5.4d), TBDY) = (ase1 \cdot A_{col1} + ase2 \cdot A_{col2} + ase3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 525.00$
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal((5.5), TBDY) = 0.032$
 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 $fs1 = fs = 525.00$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$
 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 $fs2 = fs = 525.00$
 with $Es2 = Es = 200000.00$
 $yv = 0.0021875$
 $shv = 0.008$
 $ftv = 630.00$
 $fyv = 525.00$
 $suv = 0.032$
 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 $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.12455924$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.12455924$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08458134$

and confined core properties:

$b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.14852283$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.14852283$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.1008537$

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

--->

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

--->

$su (4.9) = 0.21612757$
 $Mu = MRc (4.14) = 3.3287E+008$
 $u = su (4.1) = 0.00019626$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0215\text{E}+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215\text{E}+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$\mu_u / \mu - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 5.1583838\text{E}-012$

$V_u = 1.3805066\text{E}-030$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s3} = 0.00$ is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 420.00$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17, 10.3.4)

$2(1-s/d) = 0.00$

V_f ((11-3)-(11.4), ACI 440) = 109599.773

$f = 0.95$, 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 $V_f(\alpha)$, 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: $\alpha_1 = b_1 + 90^\circ = 90.00$

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

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 208.00

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: $V_s + V_f \leq 1.5943\text{E}+006$

$b_w = 3000.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0215\text{E}+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$\mu_u / \mu - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

h = 3000.00
d = 200.00
lw = 250.00
Mu = 5.1583838E-012
Vu = 1.3805066E-030
Nu = 27514.027

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

d = 200.00
Av = 157079.633
s = 100.00
fy = 420.00

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

d = 200.00
Av = 157079.633
s = 100.00
fy = 420.00

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

$V_{s3} = 0.00$ is calculated for web, with:

d = 200.00
Av = 0.00
s = 200.00
fy = 420.00

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.00$

V_f ((11-3)-(11.4), ACI 440) = 109599.773

f = 0.95, for fully-wrapped sections

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

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot\alpha)\sin\alpha$ 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: $\alpha_1 = b_1 + 90^\circ = 90.00$

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

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 208.00

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: $V_s + V_f \leq 1.5943E+006$

bw = 3000.00

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

According to 10.7.2.3, ASCE 41-17, shear walls with

transverse reinforcement percentage, $\gamma_n < 0.0015$

are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17

$\gamma_n = 0.0010472$

with $\gamma_n = \rho_{s1} + \rho_{s2} + \rho_{s3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 2

(pseudo-col.1 $\rho_{s1} = A_{s1} \cdot b_1 / s_1 = (A_{s1} \cdot h_1 / s_1) / A_c = 0.0005236$

$h_1 = 250.00$

$s_1 = 100.00$

total area of hoops perpendicular to shear axis, $As1 = 157.0796$
 (pseudo-col.2 $ps2 = As2*b2/s2 = (As2*h2/s2) / Ac = 0.0005236$
 $h2 = 250.00$
 $s2 = 100.00$
 total area of hoops perpendicular to shear axis, $As2 = 157.0796$
 (grid $ps3 = As3*b3/s3 = (As3*h3/s3) / Ac = 0.00$
 $h3 = 250.00$
 $s3 = 200.00$
 total area of hoops perpendicular to shear axis, $As3 = 0.00$
 total section area, $Ac = 750000.00$

Consequently:

Existing material of Primary Member: Concrete Strength, $fc = fc_lower_bound = 16.00$
 Existing material of Primary Member: Steel Strength, $fs = fs_lower_bound = 420.00$
 Concrete Elasticity, $Ec = 23025.204$
 Steel Elasticity, $Es = 200000.00$
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $Wedg = 250.00$
 Edges Height, $Hedg = 600.00$
 Web Width, $Wweb = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($lb/ld \geq 1$)
 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, $NoDir = 1$
 Fiber orientations, $bi: 0.00^\circ$
 Number of layers, $NL = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 1.8746810E-011$
 Shear Force, $V2 = 1.4270893E-014$
 Shear Force, $V3 = -25941.359$
 Axial Force, $F = -27508.271$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $Aslt = 0.00$
 -Compression: $Aslc = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl_{ten} = 2368.761$
 -Compression: $Asl_{com} = 2368.761$
 -Middle: $Asl_{mid} = 1608.495$
 Mean Diameter of Tension Reinforcement, $DbL = 17.20$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = * u = 0.0097905$
 $u = y + p = 0.0097905$

- Calculation of y -

$y = (My*Ip)/(EI)_{Eff} = 0.0017905 ((10-5), ASCE 41-17))$
 $My = 2.3485E+008$

(EI)Eff = 0.35*Ec*I (table 10-5)
Ec*I = 8.9942E+013
Ip = 0.5*d = 0.5*(0.8*h) = 240.00

Calculation of Yielding Moment My

Calculation of ρ_y and My according to Annex 7 -

y = Min(ρ_{y_ten} , ρ_{y_com})
 $\rho_{y_ten} = 1.3484639E-005$
with $f_y = 420.00$
d = 208.00
y = 0.25128485
A = 0.01027486
B = 0.00621668
with $p_t = 0.00379609$
pc = 0.00379609
pv = 0.00257772
N = 27508.271
b = 3000.00
" = 0.20192308
 $\rho_{y_comp} = 2.4018276E-005$
with f_c^* (12.3, (ACI 440)) = 16.002
fc = 16.00
fl = 0.17503396
b = 3000.00
h = 250.00
Ag = 750000.00
From (12.9), ACI 440: $k_a = 0.00364754$
g = $p_t + p_c + p_v = 0.0101699$
rc = 40.00
Ae/Ac = 0.52524587
Effective FRP thickness, $t_f = N L^* t^* \cos(\theta_1) = 1.016$
effective strain from (12.5) and (12.12), $\epsilon_{fe} = 0.004$
fu = 0.01
Ef = 64828.00
Ec = 23025.204
y = 0.25040222
A = 0.0099937
B = 0.00611172
with $E_s = 200000.00$

Calculation of ratio lb/d

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

- Calculation of ρ_p -

Considering wall controlled by flexure (shear control ratio ≤ 1),
from table 10-19: $\rho_p = 0.008$

with:

- Condition i (shear wall and wall segments)

- $(A_s - A_s') * f_y + P) / (t_w * l_w * f_c') = -0.21981824$

As = 0.00

As' = 6346.017

$f_y = 420.00$

P = 27508.271

$t_w = 3000.00$

$l_w = 250.00$

fc = 16.00

- $V / (t_w * l_w * f_c'^{0.5}) = 5.7286610E-020$, NOTE: units in lb & in

- Confined Boundary: No

Boundary hoops spacing does not exceed 8db ($s_1 < 8 * db$ and $s_2 < 8 * db$)

Boundary Trans. Reinf. does not exceed 50% of ACI 318 provision ($V_{w1} + V_{w2} > 0.50 \cdot (V - V_c - V_{w3})$)

With

Boundary Element 1:

$V_{w1} = 131946.891$

$s1 = 100.00$

Boundary Element 2:

$V_{w2} = 131946.891$

$s2 = 100.00$

Grid Shear Force, $V_{w3} = 0.00$

Concrete Shear Force, $V_c = 171403.581$

(The variables above have already been given in Shear control ratio calculation)

Mean diameter of all bars, $d_b = 17.33333$

Design Shear Force, $V = 1.4270893E-014$

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

wall W1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\phi = 1.00$
 Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
 Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 Steel Elasticity, $E_s = 200000.00$
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{o,min} = l_b/l_d \geq 1$)
 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, $M_a = 1.8746810E-011$
 Shear Force, $V_a = 1.4270893E-014$
 EDGE -B-
 Bending Moment, $M_b = 2.3754821E-011$
 Shear Force, $V_b = -1.4270893E-014$
 BOTH EDGES
 Axial Force, $F = -27508.271$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 2368.761$
 -Compression: $A_{sl,com} = 2368.761$
 -Middle: $A_{sl,mid} = 1608.495$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 527700.33$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c^{0.5} \cdot h \cdot d = 527700.33$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 159686.763$
 $\mu_u/V_u - l_w/2 = 1539.564 > 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$

d = 200.00
lw = 250.00
Mu = 2.3754821E-011
Vu = 1.4270893E-014
Nu = 27508.271

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

d = 200.00
Av = 157079.633
s = 100.00
fy = 420.00

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

d = 200.00
Av = 157079.633
s = 100.00
fy = 420.00

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

$V_{s3} = 0.00$ is calculated for web, with:

d = 200.00
Av = 0.00
s = 200.00
fy = 420.00

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.00$

$V_f ((11-3)-(11.4), \text{ACI 440}) = 109599.773$

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, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 208.00

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

$E_f = 64828.00$

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

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 1.5943E+006$

bw = 3000.00

End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 14

wall W1, Floor 1

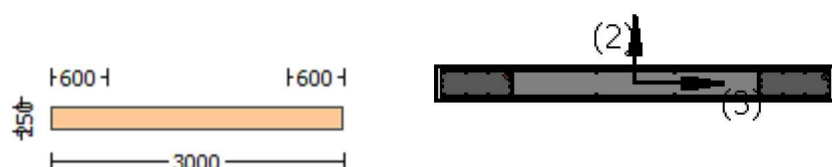
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_u)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 24.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.0097420E-028
EDGE -B-
Shear Force, Vb = 1.0097420E-028
BOTH EDGES
Axial Force, F = -27514.027
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6346.017
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2865.133
-Compression: Asl,com = 2865.133
-Middle: Asl,mid = 0.00
(According to 10.7.2.3 Asl,mid is setted equal to zero)

Calculation of Shear Capacity ratio , $V_e/V_r = 1.97404$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 7.2241E+009$
 $M_{u1+} = 6.5646E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 7.2241E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 7.2241E+009$
 $M_{u2+} = 6.5646E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $M_{u2-} = 7.2241E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.1622708E-005$
 $M_u = 6.5646E+009$

with full section properties:

b = 250.00
d = 2957.00
d' = 43.00
 $\nu = 0.00155078$
N = 27514.027
 $f_c = 24.00$
 $\phi_{co} (5A.5, TBDY) = 0.002$
Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_{cu} = 0.0035$
 $\phi_{we} ((5.4c), TBDY) = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$
where $\phi_f = a_f * \phi_{pf} * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
 $\phi_{fx} = 0.00$
 $\phi_{af} = 0.00$

b = 250.00
h = 3000.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.008128$
bw = 250.00
effective stress from (A.35), $ff,e = 748.2496$

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $ff,e = 953.7391$

R = 40.00
Effective FRP thickness, $tf = NL*t*\cos(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
 $ase((5.4d), TBDY) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x \text{ (column 1)} = (As1*h1/s_1)/Ac = 0.00125664$
h1 = 600.00
 $As1 = Astir1*ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2,x \text{ (column 2)} = (As2*h2/s_2)/Ac = 0.00125664$
h2 = 600.00
 $As2 = Astir2*ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3,x \text{ (web)} = (As3*h3/s_3)/Ac = 0.00188496$
h3 = 1800.00
 $As3 = Astir3*ns3 = 0.00$
No stirups, ns3 = 2.00

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1*h1/s_1)/Ac = 0.0005236$
h1 = 250.00
 $As1 = Astir1*ns1 = 157.0796$
No stirups, ns1 = 2.00
 $ps2,y \text{ (column 2)} = (As2*h2/s_2)/Ac = 0.0005236$
h2 = 250.00
 $As2 = Astir2*ns2 = 157.0796$
No stirups, ns2 = 2.00
 $ps3,y \text{ (web)} = (As3*h3/s_3)/Ac = 0.00$
h3 = 250.00
 $As3 = Astir3*ns3 = 157.0796$
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 656.25
fce = 24.00

From ((5.A.5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$
 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 $fs1 = fs = 656.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
 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.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 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 $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.10597696$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.10597696$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.00$
 and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.14087258$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.14087258$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.00$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.06891069$$

$$M_u = M_{Rc}(4.14) = 6.5646E+009$$

$$u = s_u(4.1) = 1.1622708E-005$$

Calculation of ratio I_b/I_d

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

Calculation of M_{u1} -

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

$$\kappa_u = 1.1719585E-005$$

$$M_u = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

$$\text{Final value of } \kappa_u: \kappa_u^* = \text{shear_factor} * \text{Max}(\kappa_u, \kappa_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \kappa_u = 0.0035$$

$$\omega_{se}((5.4c), TBDY) = \alpha_{se} * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$f_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00

fywe = 656.25
fce = 24.00

From ((5.A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

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

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

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s2} = f_s = 656.25$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
 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
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = f_s = 656.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.10597696$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.10597696$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02277575$
 and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03027525$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.07660732$
 $Mu = MR_c (4.14) = 7.2241E+009$
 $u = su (4.1) = 1.1719585E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_{2+}

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

$u = 1.1622708E-005$
 $Mu = 6.5646E+009$

with full section properties:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.0035$

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

From (5.4b), TBDY: $c_u = 0.0035$

w_e ((5.4c), TBDY) = $a_{se} * sh_{min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$

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_{se} ((5.4d), TBDY) = $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi2_1 = 655400.00$

$a_{se2} = 0.00$

$sh_2 = 100.00$

$bo_2 = 190.00$

$ho_2 = 540.00$

$bi2_2 = 655400.00$

$a_{se3} = 0$ (grid does not provide confinement)

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$

$p_{s1,x}$ (column 1) = $(A_{s1} * h_1 / s_1) / A_c = 0.00125664$

$h_1 = 600.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirups, $n_{s1} = 2.00$

$p_{s2,x}$ (column 2) = $(A_{s2} * h_2 / s_2) / A_c = 0.00125664$

$h_2 = 600.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirups, $n_{s2} = 2.00$

$p_{s3,x}$ (web) = $(A_{s3} * h_3 / s_3) / A_c = 0.00188496$

$h_3 = 1800.00$

$A_{s3} = A_{stir3} * n_{s3} = 0.00$

No stirups, $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$

$p_{s1,y}$ (column 1) = $(A_{s1} * h_1 / s_1) / A_c = 0.0005236$

$h_1 = 250.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirups, $n_{s1} = 2.00$

$p_{s2,y}$ (column 2) = $(A_{s2} * h_2 / s_2) / A_c = 0.0005236$

$h_2 = 250.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirups, $n_{s2} = 2.00$

$p_{s3,y}$ (web) = $(A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3} * n_{s3} = 157.0796$

No stirups, $n_{s3} = 0.00$

```

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 656.25
fce = 24.00
From ((5.A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386

```


$c = \text{confinement factor} = 1.00339$

$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$

$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u(4.9) = 0.06891069$

$M_u = M_{Rc}(4.14) = 6.5646E+009$

$u = s_u(4.1) = 1.1622708E-005$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2} -

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

$u = 1.1719585E-005$

$M_u = 7.2241E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

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

Final value of α : $\alpha = \text{shear_factor} * \text{Max}(\alpha_c, \alpha_s) = 0.0035$

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

From (5.4b), TBDY: $\alpha = 0.0035$

$\alpha_{we}((5.4c), TBDY) = \alpha * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.00$

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

$\alpha_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$\alpha_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$

Effective FRP thickness, $t_f = N L * t * \text{Cos}(\theta_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web})/A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \text{Min}(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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 $fs_2 = fs = 656.25$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
 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 $fsv = fs = 656.25$
 with $Es_v = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.10597696$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.10597696$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.02277575$
 and confined core properties:
 $b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.14087258$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.14087258$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.03027525$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.07660732$
 $Mu = MRc (4.14) = 7.2241E+009$
 $u = su (4.1) = 1.1719585E-005$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 * f_c'^{0.5} * h * d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u/V_u - l_w/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f'_c = 24.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 240.00$
 $l_w = 3000.00$
 $\mu_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 V_f ((11-3)-(11.4), ACI 440) = $1.5581E+006$
 $f = 0.95$, 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: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 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: $V_s + V_f \leq 1.9526E+006$
 $b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f'_c^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$
 $\mu_u/V_u - l_w/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f'_c = 24.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 240.00$
 $l_w = 3000.00$
 $\mu_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$

$f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$
 $f = 0.95$, 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, $t_{f1} = N_L * t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526\text{E}+006$
 $b_w = 250.00$

 End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 3

 Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcrws

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 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
 Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$
 #####
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00339
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 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, $V_a = -1.3805066E-030$
 EDGE -B-
 Shear Force, $V_b = 1.3805066E-030$
 BOTH EDGES
 Axial Force, $F = -27514.027$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 2368.761$
 -Compression: $A_{st,com} = 2368.761$
 -Middle: $A_{st,mid} = 0.00$
 (According to 10.7.2.3 $A_{st,mid}$ is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21724146$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3287E+008$
 $\mu_{u1+} = 2.5476E+008$, 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
 $\mu_{u1-} = 3.3287E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 3.3287E+008$
 $\mu_{u2+} = 2.5476E+008$, 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
 $\mu_{u2-} = 3.3287E+008$, 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 μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 0.00019036$
 $M_u = 2.5476E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$

$$f_c = 16.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \alpha = 0.0035$$

$$\alpha_e \text{ ((5.4c), TBDY) } = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.00$$

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

$$\alpha_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\alpha_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \rho_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$\alpha_{se} \text{ ((5.4d), TBDY) } = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$\alpha_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\rho_{sh,\min} = \text{Min}(\rho_{sh,x}, \rho_{sh,y}) = 0.0010472$$

$$\rho_{sh,x} = \rho_{s1,x} + \rho_{s2,x} + \rho_{s3,x} = 0.00439823$$

$$\rho_{s1,x} \text{ (column 1) } = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$\rho_{s2,x} \text{ (column 2) } = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$\rho_{s3,x} \text{ (web) } = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$\rho_{sh,y} = \rho_{s1,y} + \rho_{s2,y} + \rho_{s3,y} = 0.0010472$$

$$\rho_{s1,y} \text{ (column 1) } = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$\rho_{s2,y} \text{ (column 2) } = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$$

$$h_2 = 250.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$\rho_{s3,y} \text{ (web) } = (A_{s3} * h_3 / s_3) / A_c = 0.00$$

h3 = 250.00
 As3 = Astir3*ns3 = 157.0796
 No stirups, ns3 = 0.00

Asec = 750000.00

s_1 = 100.00

s_2 = 100.00

s_3 = 200.00

fywe = 525.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386

c = confinement factor = 1.00339

y1 = 0.0021875

sh1 = 0.008

ft1 = 630.00

fy1 = 525.00

su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 525.00

with Es1 = Es = 200000.00

y2 = 0.0021875

sh2 = 0.008

ft2 = 630.00

fy2 = 525.00

su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 525.00

with Es2 = Es = 200000.00

yv = 0.0021875

shv = 0.008

ftv = 630.00

fyv = 525.00

suv = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

with fsv = fs = 525.00

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924

2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924

v = Asl,mid/(b*d)*(fsv/fc) = 0.00

and confined core properties:

b = 2940.00

d = 178.00


```

d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269
Mu = MRc (4.14) = 2.5476E+008
u = su (4.1) = 0.00019036

```

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 = 0.00019626
Mu = 3.3287E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.00
where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```

```

fx = 0.00
af = 0.00
b = 250.00
h = 3000.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 636.1644

```

```

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00067733
bw = 3000.00
effective stress from (A.35), ff,e = 944.3987

```

```

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*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00

```

```

ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

```

```

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (column 1) = (As1*h1/s_1)/Ac = 0.00125664
h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (column 2) = (As2*h2/s_2)/Ac = 0.00125664
h2 = 600.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,x (web) = (As3*h3/s_3)/Ac = 0.00188496
h3 = 1800.00
As3 = Astir3*ns3 = 0.00
No stirups, ns3 = 2.00

```

```

psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
h1 = 250.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
h2 = 250.00
As2 = Astir2*ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
h3 = 250.00
As3 = Astir3*ns3 = 157.0796
No stirups, ns3 = 0.00

```

```

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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 = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008

```

```

ft2 = 630.00
fy2 = 525.00
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 = 525.00
    with Es2 = Es = 200000.00
    yv = 0.0021875
    shv = 0.008
    ftv = 630.00
    fyv = 525.00
    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 = 525.00
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
    2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.21612757
Mu = MRc (4.14) = 3.3287E+008
u = su (4.1) = 0.00019626

```

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 = 0.00019036
Mu = 2.5476E+008

```

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.0035$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.0035$$

$$\alpha_e ((5.4c), \text{TB DY}) = \alpha * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\alpha_x, \alpha_y) = 0.00$$

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

$$\alpha_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } \rho_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\alpha_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } \rho_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$\alpha_{se} ((5.4d), \text{TB DY}) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

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

$$\text{bo}_1 = 190.00$$

$$\text{ho}_1 = 540.00$$

$$\text{bi2}_1 = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$\text{sh}_2 = 100.00$$

$$\text{bo}_2 = 190.00$$

$$\text{ho}_2 = 540.00$$

$$\text{bi2}_2 = 655400.00$$

$$\alpha_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\text{psh}_{\min} = \text{Min}(\text{psh}_x, \text{psh}_y) = 0.0010472$$

$$\text{psh}_x = \text{ps1}_x + \text{ps2}_x + \text{ps3}_x = 0.00439823$$

$$\text{ps1}_x \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$\text{ps2}_x \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$\text{ps3}_x \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$\text{psh}_y = \text{ps1}_y + \text{ps2}_y + \text{ps3}_y = 0.0010472$$

$$\text{ps1}_y \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

 $Asec = 750000.00$

$s_1 = 100.00$

$s_2 = 100.00$

$s_3 = 200.00$

$fywe = 525.00$

$fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$

$c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$

$sh1 = 0.008$

$ft1 = 630.00$

$fy1 = 525.00$

$su1 = 0.032$

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 $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$

$sh2 = 0.008$

$ft2 = 630.00$

$fy2 = 525.00$

$su2 = 0.032$

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.

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = fs = 525.00$

with $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

$suv = 0.032$

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

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

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

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

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

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

with $fsv = fs = 525.00$

with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.12455924$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12455924$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.1918269$
 $Mu = MR_c (4.14) = 2.5476E+008$
 $u = su (4.1) = 0.00019036$

Calculation of ratio l_b/d

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

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00019626$
 $Mu = 3.3287E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.0035$
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$
where $f = a_f * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

 $f_x = 0.00$
 $a_f = 0.00$
 $b = 250.00$
 $h = 3000.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.008128$
 $bw = 250.00$
effective stress from (A.35), $f_{f,e} = 636.1644$

$f_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
From EC8 A.4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
 $bw = 3000.00$
effective stress from (A.35), $f_{f,e} = 944.3987$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase((5.4d), TBDY) = (ase1 \cdot A_{col1} + ase2 \cdot A_{col2} + ase3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 525.00$
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339

$y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$
 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
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal((5.5), TBDY) = 0.032$
 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 $fs1 = fs = 525.00$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$
 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 $fs2 = fs = 525.00$
 with $Es2 = Es = 200000.00$
 $yv = 0.0021875$
 $shv = 0.008$
 $ftv = 630.00$
 $fyv = 525.00$
 $suv = 0.032$
 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 $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.12455924$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.12455924$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08458134$

and confined core properties:

$b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.14852283$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.14852283$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.1008537$

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

--->

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

--->

$su (4.9) = 0.21612757$
 $Mu = MRc (4.14) = 3.3287E+008$
 $u = su (4.1) = 0.00019626$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$\mu_u / \mu - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 5.1583838E-012$

$V_u = 1.3805066E-030$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s2} = 131946.891$ is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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

$V_{s3} = 0.00$ is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 420.00$

V_{s3} has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17, 10.3.4)

$2(1-s/d) = 0.00$

V_f ((11-3)-(11.4), ACI 440) = 109599.773

$f = 0.95$, 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: $\theta_1 = b_1 + 90^\circ = 90.00$

$V_f = \min(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:

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

$d_{fv} = d$ (figure 11.2, ACI 440) = 208.00

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: $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0215E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$\mu_u / \mu - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

```

h = 3000.00
d = 200.00
lw = 250.00
Mu = 5.1583838E-012
Vu = 1.3805066E-030
Nu = 27514.027
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$ 
 $V_{s1} = 131946.891$  is calculated for pseudo-Column 1, with:
d = 200.00
 $A_v = 157079.633$ 
s = 100.00
 $f_y = 420.00$ 
 $V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)
 $V_{s2} = 131946.891$  is calculated for pseudo-Column 2, with:
d = 200.00
 $A_v = 157079.633$ 
s = 100.00
 $f_y = 420.00$ 
 $V_{s2}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)
 $V_{s3} = 0.00$  is calculated for web, with:
d = 200.00
 $A_v = 0.00$ 
s = 200.00
 $f_y = 420.00$ 
 $V_{s3}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.00$ 
 $V_f ((11-3)-(11.4), ACI 440) = 109599.773$ 
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  $(\cot + \cot\alpha)\sin\alpha$  which is more a generalised expression,
where  $\alpha$  is the angle of the crack direction (see KANEPE).
This later relation, considered as a function  $V_f( , )$ , is implemented for every different fiber orientation  $\alpha_i$ ,
as well as for 2 crack directions,  $\alpha = 45^\circ$  and  $\alpha = -45^\circ$  to take into consideration the cyclic seismic loading.
orientation 1:  $\alpha_1 = b_1 + 90^\circ = 90.00$ 
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, \alpha_1)|)$ , with:
total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.016$ 
 $d_{fv} = d$  (figure 11.2, ACI 440) = 208.00
 $f_{fe} ((11-5), ACI 440) = 259.312$ 
 $E_f = 64828.00$ 
 $f_e = 0.004$ , from (11.6a), ACI 440
with  $f_u = 0.01$ 
From (11-11), ACI 440:  $V_s + V_f \leq 1.5943E+006$ 
bw = 3000.00

```

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$
According to 10.7.2.3, ASCE 41-17, shear walls with
transverse reinforcement percentage, $\gamma_n < 0.0015$
are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17
 $\gamma_n = 0.0010472$

with $\gamma_n = \rho_{s1} + \rho_{s2} + \rho_{s3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 3
(pseudo-col.1 $\rho_{s1} = A_{s1} * b_1 / s_1 = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $s_1 = 100.00$

total area of hoops perpendicular to shear axis, $As1 = 157.0796$
 (pseudo-col.2 $ps2 = As2*b2/s2 = (As2*h2/s2) / Ac = 0.0005236$
 $h2 = 250.00$
 $s2 = 100.00$
 total area of hoops perpendicular to shear axis, $As2 = 157.0796$
 (grid $ps3 = As3*b3/s3 = (As3*h3/s3) / Ac = 0.00$
 $h3 = 250.00$
 $s3 = 200.00$
 total area of hoops perpendicular to shear axis, $As3 = 0.00$
 total section area, $Ac = 750000.00$

Consequently:

Existing material of Primary Member: Concrete Strength, $fc = fc_lower_bound = 16.00$
 Existing material of Primary Member: Steel Strength, $fs = fs_lower_bound = 420.00$
 Concrete Elasticity, $Ec = 23025.204$
 Steel Elasticity, $Es = 200000.00$
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $Wedg = 250.00$
 Edges Height, $Hedg = 600.00$
 Web Width, $Wweb = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($lb/l_d \geq 1$)
 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, $NoDir = 1$
 Fiber orientations, $bi: 0.00^\circ$
 Number of layers, $NL = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Axial Force, $F = -27508.271$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_{lt} = 0.00$
 -Compression: $As_{lc} = 6346.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{l,ten} = 2865.133$
 -Compression: $As_{l,com} = 2865.133$
 -Middle: $As_{l,mid} = 615.7522$
 Mean Diameter of Tension Reinforcement, $DbL = 17.33333$

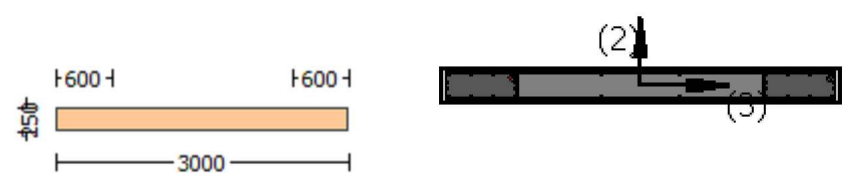
Considering wall controlled by Shear (shear control ratio > 1),
 interstorey drift provided values are calculated
 Existing component: From table 7-7, ASCE 41_17: Final interstorey drift Capacity $u_{i,R} = * u = 0.015$
 from table 10-20: $u = 0.015$
 with:
 - Condition i (shear wall and wall segments)
 - $(As - As')*fy + P)/(tw*lw*fc') = -0.21981824$
 $As = 0.00$
 $As' = 6346.017$
 $fy = 420.00$
 $P = 27508.271$

tw = 250.00
lw = 3000.00
fc = 16.00

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 15

wall W1, Floor 1
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity VRd
Edge: End
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcwrs

Constant Properties

Knowledge Factor, = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204
Steel Elasticity, Es = 200000.00
Total Height, Htot = 3000.00

Edges Width, Wedg = 250.00
 Edges Height, Hedg = 600.00
 Web Width, Wweb = 250.00
 Cover Thickness, c = 25.00
 Element Length, L = 3000.00
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
 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, b_i : 0.00°
 Number of layers, NL = 1
 Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
 Bending Moment, M_a = 7.7834E+007
 Shear Force, V_a = -25941.359
 EDGE -B-
 Bending Moment, M_b = -1864.942
 Shear Force, V_b = 25941.359
 BOTH EDGES
 Axial Force, F = -27508.271
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t}$ = 0.00
 -Compression: $A_{sl,c}$ = 6346.017
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten}$ = 2865.133
 -Compression: $A_{sl,com}$ = 2865.133
 -Middle: $A_{sl,mid}$ = 615.7522
 Mean Diameter of Tension Reinforcement, $Db_{L,ten}$ = 17.33333

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 1.9920E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d = 1.9920E+006$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653501.654$
 $M_u/V_u - l_w/2 = -1499.928 \leq 0$
 = 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $M_u = 1864.942$
 $V_u = 25941.359$
 $N_u = 27508.271$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.1084E+006$
 $V_{s1} = 316672.539$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$

$f_y = 420.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 316672.539$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 420.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 475008.809$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 420.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 $\ln(11.3) \sin + \cos$ 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, $t_{f1} = N_L * t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.5943\text{E}+006$
 $b_w = 250.00$

 End Of Calculation of Shear Capacity for element: wall W1 of floor 1
 At local axis: 3
 Integration Section: (b)

Calculation No. 16

wall W1, Floor 1
 Limit State: Life Safety (data interpolation between analysis steps 1 and 2)
 Analysis: Uniform +X
 Check: Chord rotation capacity (θ_u)
 Edge: End
 Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrcws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 24.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 23025.204$

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Total Height, $H_{tot} = 3000.00$

Edges Width, $W_{edg} = 250.00$

Edges Height, $H_{edg} = 600.00$

Web Width, $W_{web} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00339

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

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, $V_a = -1.0097420E-028$

EDGE -B-

Shear Force, $V_b = 1.0097420E-028$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 2865.133$

-Compression: $As_{c,com} = 2865.133$

-Middle: $As_{mid} = 0.00$

(According to 10.7.2.3 As_{mid} is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 1.97404$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 4.8160E+006$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 7.2241E+009$

$Mu_{1+} = 6.5646E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 7.2241E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 7.2241E+009$

$Mu_{2+} = 6.5646E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 7.2241E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 1.1622708E-005$

$M_u = 6.5646E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$

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

From (5.4b), TBDY: $\phi_u = 0.0035$

ϕ_{we} ((5.4c), TBDY) = $a s_e * \phi_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

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

$\phi_x = 0.00$

$a f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $\phi_f = 2 t_f / b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$\phi_y = 0.00$

$a f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $\phi_f = 2 t_f / b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_f = 0.015$
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase_3 = 0$ (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / A_c = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / A_c = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / A_c = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 c = confinement factor = 1.00339

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal((5.5), TBDY) = 0.032$
 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 $fs1 = fs = 656.25$
with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
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 $fs2 = fs = 656.25$
with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
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 $fsv = fs = 656.25$
with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.10597696$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.10597696$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.00$

and confined core properties:

$b = 190.00$
 $d = 2927.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 24.08126$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.14087258$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.14087258$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.00$

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

--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.06891069$
 $Mu = MRc (4.14) = 6.5646E+009$
 $u = su (4.1) = 1.1622708E-005$

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 1.1719585E-005$$

$$Mu = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.0035$$

$$w_e((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h_1} = 100.00$$

$$b_{o_1} = 190.00$$

$$h_{o_1} = 540.00$$

$$b_{i2_1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h_2} = 100.00$$

$$b_{o_2} = 190.00$$

$$h_{o_2} = 540.00$$

$$b_{i2_2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

h3 = 1800.00
 As3 = Astir3*ns3 = 0.00
 No stirups, ns3 = 2.00

 psh,y = ps1,y+ps2,y+ps3,y = 0.0010472
 ps1,y (column 1) = (As1*h1/s_1)/Ac = 0.0005236
 h1 = 250.00
 As1 = Astir1*ns1 = 157.0796
 No stirups, ns1 = 2.00
 ps2,y (column 2) = (As2*h2/s_2)/Ac = 0.0005236
 h2 = 250.00
 As2 = Astir2*ns2 = 157.0796
 No stirups, ns2 = 2.00
 ps3,y (web) = (As3*h3/s_3)/Ac = 0.00
 h3 = 250.00
 As3 = Astir3*ns3 = 157.0796
 No stirups, ns3 = 0.00

 Asec = 750000.00
 s_1 = 100.00
 s_2 = 100.00
 s_3 = 200.00

fywe = 656.25
 fce = 24.00

From ((5.A5), TBDY), TBDY: cc = 0.00203386
 c = confinement factor = 1.00339

y1 = 0.0025
 sh1 = 0.008
 ft1 = 787.50
 fy1 = 656.25
 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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
 sh2 = 0.008
 ft2 = 787.50
 fy2 = 656.25
 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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
 shv = 0.008
 ftv = 787.50
 fyv = 656.25
 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/d)^2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

u = 1.1622708E-005

Mu = 6.5646E+009

with full section properties:

b = 250.00

d = 2957.00

d' = 43.00

v = 0.00155078

N = 27514.027

fc = 24.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.0035

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

From (5.4b), TBDY: cu = 0.0035

we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min(fx, fy) = 0.00

where f = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

fx = 0.00

af = 0.00

b = 250.00

h = 3000.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

bw = 250.00

effective stress from (A.35), ffe = 748.2496

$f_y = 0.00$
 $a_f = 0.00$
 $b = 3000.00$
 $h = 250.00$
 From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
 $bw = 3000.00$
 effective stress from (A.35), $f_{f,e} = 953.7391$

$R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$
 $a_{se1} = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $a_{se2} = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $a_{se3} = 0$ (grid does not provide confinement)
 $p_{sh,min} = \min(p_{sh,x}, p_{sh,y}) = 0.0010472$

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$
 $p_{s1,x}$ (column 1) = $(A_{s1} * h_1 / s_1) / A_c = 0.00125664$
 $h_1 = 600.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $p_{s2,x}$ (column 2) = $(A_{s2} * h_2 / s_2) / A_c = 0.00125664$
 $h_2 = 600.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$
 No stirups, $n_{s2} = 2.00$
 $p_{s3,x}$ (web) = $(A_{s3} * h_3 / s_3) / A_c = 0.00188496$
 $h_3 = 1800.00$
 $A_{s3} = A_{stir3} * n_{s3} = 0.00$
 No stirups, $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$
 $p_{s1,y}$ (column 1) = $(A_{s1} * h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$
 No stirups, $n_{s1} = 2.00$
 $p_{s2,y}$ (column 2) = $(A_{s2} * h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$
 No stirups, $n_{s2} = 2.00$
 $p_{s3,y}$ (web) = $(A_{s3} * h_3 / s_3) / A_c = 0.00$
 $h_3 = 250.00$
 $A_{s3} = A_{stir3} * n_{s3} = 157.0796$
 No stirups, $n_{s3} = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 24.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c =$ confinement factor = 1.00339
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$

```

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)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
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)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.06891069
Mu = MRc (4.14) = 6.5646E+009
u = su (4.1) = 1.1622708E-005

```

Calculation of ratio l_b/d

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

Calculation of μ_2

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

$\mu = 1.1719585E-005$

$\mu_2 = 7.2241E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

α (5A.5, TBDY) = 0.002

Final value of μ : $\mu^* = \text{shear_factor} * \text{Max}(\mu, \mu_c) = 0.0035$

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

From (5.4b), TBDY: $\mu = 0.0035$

μ_e ((5.4c), TBDY) = $\alpha \cdot \text{sh_min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$\mu_{f,f} = 0.015$

α_{se} ((5.4d), TBDY) = $(\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi2_1 = 655400.00$

$\alpha_{se2} = 0.00$

$sh_2 = 100.00$

$bo_2 = 190.00$

$ho_2 = 540.00$

$bi2_2 = 655400.00$

$\alpha_{se3} = 0$ (grid does not provide confinement)

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$

$p_{s1,x}$ (column 1) = $(A_{s1} * h_1 / s_1) / A_c = 0.00125664$

$h_1 = 600.00$

$As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 * ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 * h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 * ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 * ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 * ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$

$fywe = 656.25$
 $fce = 24.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 787.50$
 $fy1 = 656.25$
 $su1 = 0.032$

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 $fs1 = fs = 656.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$

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 $fs2 = fs = 656.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$
 $shv = 0.008$

```

ftv = 787.50
fyv = 656.25
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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.10597696
    2 = Asl,com/(b*d)*(fs2/fc) = 0.10597696
    v = Asl,mid/(b*d)*(fsv/fc) = 0.02277575
and confined core properties:
b = 190.00
d = 2927.00
d' = 13.00
fcc (5A.2, TBDY) = 24.08126
cc (5A.5, TBDY) = 0.00203386
    c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14087258
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14087258
    v = Asl,mid/(b*d)*(fsv/fc) = 0.03027525
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.07660732
Mu = MRc (4.14) = 7.2241E+009
u = su (4.1) = 1.1719585E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 2.4397\text{E}+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 2.4397\text{E}+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83*fc'^{0.5}*h*d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$

$\mu_u/V_u - l_w/2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$fc' = 24.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 6.1798626\text{E}-010$

$V_u = 1.0097420\text{E}-028$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854\text{E}+006$

$V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$
 V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$
 $f = 0.95$, 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: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 1.9526\text{E}+006$
 $b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 2.4397\text{E}+006$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r2} = V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 799137.482$
 $\mu_u / \mu_u - l_w / 2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 24.00$, but $f_c' \cdot 0.5 \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $\mu_u = 6.1798626\text{E}-010$
 $\mu_u = 1.0097420\text{E}-028$
 $N_u = 27514.027$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854\text{E}+006$
 $V_{s1} = 395840.674$ is calculated for pseudo-Column 1, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s1} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s2} = 395840.674$ is calculated for pseudo-Column 2, with:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$
 $f_y = 525.00$
 V_{s2} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $V_{s3} = 593761.012$ is calculated for web, with:
 $d = 1440.00$
 $A_v = 157079.633$
 $s = 200.00$
 $f_y = 525.00$

V_{s3} has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$
 $f = 0.95$, 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, $t_{f1} = NL * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 2957.00
 $f_{fe} ((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 1.9526\text{E}+006$
 $b_w = 250.00$

 End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At local axis: 3

 Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcrcws

Constant Properties

 Knowledge Factor, $K = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 23025.204$
 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
 Existing material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$
 #####
 Total Height, $H_{tot} = 3000.00$
 Edges Width, $W_{edg} = 250.00$
 Edges Height, $H_{edg} = 600.00$
 Web Width, $W_{web} = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00339
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
 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, $\text{NoDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -1.3805066E-030$

EDGE -B-

Shear Force, $V_b = 1.3805066E-030$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 2368.761$

-Compression: $As_{c,com} = 2368.761$

-Middle: $As_{mid} = 0.00$

(According to 10.7.2.3 As_{mid} is setted equal to zero)

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21724146$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221915.706$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.3287E+008$

$\mu_{1+} = 2.5476E+008$, 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

$\mu_{1-} = 3.3287E+008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.3287E+008$

$\mu_{2+} = 2.5476E+008$, 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

$\mu_{2-} = 3.3287E+008$, 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:

$\mu = 0.00019036$

$\mu_{1+} = 2.5476E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

α_1 (5A.5, TBDY) = 0.002

Final value of μ : $\mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_s) = 0.0035$

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

From (5.4b), TBDY: $\mu_c = 0.0035$

μ_s ((5.4c), TBDY) = $\alpha_1 * \text{sh}_{min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where $f = \alpha_1 * p_f * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.008128$

bw = 250.00
effective stress from (A.35), $f_{f,e} = 636.1644$

fy = 0.00
af = 0.00
b = 3000.00
h = 250.00
From EC8 A4.4.3(6), $p_f = 2t_f/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $f_{f,e} = 944.3987$

R = 40.00
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = $(ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
ase1 = 0.00
sh_1 = 100.00
bo_1 = 190.00
ho_1 = 540.00
bi2_1 = 655400.00
ase2 = 0.00
sh_2 = 100.00
bo_2 = 190.00
ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = Min(psh,x , psh,y) = 0.0010472

psh,x = $ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}$ (column 1) = $(As_1 \cdot h_1 / s_1) / A_c = 0.00125664$
h1 = 600.00
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, ns1 = 2.00
 $ps_{2,x}$ (column 2) = $(As_2 \cdot h_2 / s_2) / A_c = 0.00125664$
h2 = 600.00
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, ns2 = 2.00
 $ps_{3,x}$ (web) = $(As_3 \cdot h_3 / s_3) / A_c = 0.00188496$
h3 = 1800.00
 $As_3 = Astir_3 \cdot ns_3 = 0.00$
No stirups, ns3 = 2.00

psh,y = $ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}$ (column 1) = $(As_1 \cdot h_1 / s_1) / A_c = 0.0005236$
h1 = 250.00
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
No stirups, ns1 = 2.00
 $ps_{2,y}$ (column 2) = $(As_2 \cdot h_2 / s_2) / A_c = 0.0005236$
h2 = 250.00
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
No stirups, ns2 = 2.00
 $ps_{3,y}$ (web) = $(As_3 \cdot h_3 / s_3) / A_c = 0.00$
h3 = 250.00
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$
No stirups, ns3 = 0.00

Asec = 750000.00
s_1 = 100.00
s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5.A5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875

```

sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
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)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = fs = 525.00
    with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
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 = 525.00
    with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 525.00
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
    c = confinement factor = 1.00339
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
    v = Asl,mid/(b*d)*(fsv/fc) = 0.00
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1918269

```

$$\begin{aligned} \mu_u &= M_{Rc} (4.14) = 2.5476E+008 \\ u &= s_u (4.1) = 0.00019036 \end{aligned}$$

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:

$$\begin{aligned} u &= 0.00019626 \\ \mu_u &= 3.3287E+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 3000.00 \\ d &= 208.00 \\ d' &= 42.00 \\ v &= 0.00275581 \\ N &= 27514.027 \end{aligned}$$

$$\begin{aligned} f_c &= 16.00 \\ c_o (5A.5, TBDY) &= 0.002 \end{aligned}$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.0035$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h,1} = 100.00$$

$$b_{o,1} = 190.00$$

$$h_{o,1} = 540.00$$

$$b_{i2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h,2} = 100.00$$

$$b_{o,2} = 190.00$$

$$h_{o,2} = 540.00$$

$$b_{i2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 525.00$
 $fce = 16.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$

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

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

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

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 $fs1 = fs = 525.00$

with $Es1 = Es = 200000.00$

$y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$

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

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

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

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

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

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

with $fs2 = fs = 525.00$

```

with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283
v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21612757
Mu = MRc (4.14) = 3.3287E+008
u = su (4.1) = 0.00019626

```

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 = 0.00019036
Mu = 2.5476E+008

```

with full section properties:

```

b = 3000.00
d = 208.00
d' = 42.00
v = 0.00275581
N = 27514.027
fc = 16.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0035
we ((5.4c), TBDY) = ase* sh,min*fywe/fce+Min( fx, fy) = 0.00

```

where $f = af \cdot pf \cdot ffe / fce$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$
 $af = 0.00$
 $b = 250.00$
 $h = 3000.00$
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.008128$
 $bw = 250.00$
effective stress from (A.35), $ff,e = 636.1644$

$f_y = 0.00$
 $af = 0.00$
 $b = 3000.00$
 $h = 250.00$
From EC8 A.4.4.3(6), $pf = 2tf/bw = 0.00067733$
 $bw = 3000.00$
effective stress from (A.35), $ff,e = 944.3987$

$R = 40.00$
Effective FRP thickness, $tf = NL \cdot t \cdot \cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), TBDY) = (ase1 \cdot A_{col1} + ase2 \cdot A_{col2} + ase3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \min(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
No stirups, $ns3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$

```

s_2 = 100.00
s_3 = 200.00
fywe = 525.00
fce = 16.00
From ((5A.5), TBDY), TBDY: cc = 0.00203386
c = confinement factor = 1.00339
y1 = 0.0021875
sh1 = 0.008
ft1 = 630.00
fy1 = 525.00
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 525.00
with Es1 = Es = 200000.00
y2 = 0.0021875
sh2 = 0.008
ft2 = 630.00
fy2 = 525.00
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 525.00
with Es2 = Es = 200000.00
yv = 0.0021875
shv = 0.008
ftv = 630.00
fyv = 525.00
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 = 525.00
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924
2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924
v = Asl,mid/(b*d)*(fsv/fc) = 0.00
and confined core properties:
b = 2940.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 16.05417
cc (5A.5, TBDY) = 0.00203386
c = confinement factor = 1.00339
1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283
2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.00$$

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

--->

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

--->

$$s_u(4.9) = 0.1918269$$

$$\mu_u = M_{Rc}(4.14) = 2.5476E+008$$

$$u = s_u(4.1) = 0.00019036$$

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:

$$u = 0.00019626$$

$$\mu_u = 3.3287E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear_factor} \cdot \text{Max}(\mu_{cu}, \mu_{cc}) = 0.0035$$

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

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.0035$$

$$\omega_e((5.4c), TBDY) = a_{se} \cdot \text{sh}_{\min} \cdot f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A4.4.3(6), } p_f = 2t_f/bw = 0.00067733$$

$$bw = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

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

$$a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (grid does not provide confinement)
 $psh,min = \text{Min}(psh,x, psh,y) = 0.0010472$

$psh,x = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.00125664$
 $h2 = 600.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00188496$
 $h3 = 1800.00$
 $As3 = Astir3 \cdot ns3 = 0.00$
 No stirups, $ns3 = 2.00$

$psh,y = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(As1 \cdot h1 / s_1) / Ac = 0.0005236$
 $h1 = 250.00$
 $As1 = Astir1 \cdot ns1 = 157.0796$
 No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(As2 \cdot h2 / s_2) / Ac = 0.0005236$
 $h2 = 250.00$
 $As2 = Astir2 \cdot ns2 = 157.0796$
 No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(As3 \cdot h3 / s_3) / Ac = 0.00$
 $h3 = 250.00$
 $As3 = Astir3 \cdot ns3 = 157.0796$
 No stirups, $ns3 = 0.00$

$Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fywe = 525.00$
 $fce = 16.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $y1 = 0.0021875$
 $sh1 = 0.008$
 $ft1 = 630.00$
 $fy1 = 525.00$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal$ ((5.5), TBDY) = 0.032
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 525.00$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0021875$
 $sh2 = 0.008$
 $ft2 = 630.00$
 $fy2 = 525.00$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = fs = 525.00$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0021875$
 $sh_v = 0.008$
 $ft_v = 630.00$
 $fy_v = 525.00$
 $suv = 0.032$
 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 $fsyv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = fs = 525.00$
 with $Es_v = Es = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(fs_1/f_c) = 0.12455924$
 $2 = A_{sl,com}/(b*d)*(fs_2/f_c) = 0.12455924$
 $v = A_{sl,mid}/(b*d)*(fs_v/f_c) = 0.08458134$
 and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(fs_1/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b*d)*(fs_2/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b*d)*(fs_v/f_c) = 0.1008537$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21612757$
 $Mu = MR_c (4.14) = 3.3287E+008$
 $u = su (4.1) = 0.00019626$

 Calculation of ratio l_b/l_d

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

 Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_{r1} = V_n < 0.83 * f_c'^{0.5} * h * d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$
 $Mu/V_u - l_w/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$
 $d = 200.00$
 $lw = 250.00$
 $Mu = 5.1583838E-012$
 $Vu = 1.3805066E-030$
 $Nu = 27514.027$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 + Vs3 = 263893.783$
 $Vs1 = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $Av = 157079.633$
 $s = 100.00$
 $fy = 420.00$
 $Vs1$ has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $Vs2 = 131946.891$ is calculated for pseudo-Column 2, with:
 $d = 200.00$
 $Av = 157079.633$
 $s = 100.00$
 $fy = 420.00$
 $Vs2$ has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)
 $Vs3 = 0.00$ is calculated for web, with:
 $d = 200.00$
 $Av = 0.00$
 $s = 200.00$
 $fy = 420.00$
 $Vs3$ has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)
 $2(1-s/d) = 0.00$
 Vf ((11-3)-(11.4), ACI 440) = 109599.773
 $f = 0.95$, 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 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: $a_1 = b_1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, 1)|, |Vf(-45, a_1)|)$, with:
 total thickness per orientation, $tf1 = NL \cdot t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 208.00
 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: $Vs + Vf \leq 1.5943E+006$
 $bw = 3000.00$

 Calculation of Shear Strength at edge 2, $Vr2 = 1.0215E+006$
 From (22.5.1.1) and 11.5.4.3, ACI 318-14: $Vr2 = Vn < 0.83 \cdot fc'^{0.5} \cdot h \cdot d$

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

From Table (11.5.4.6(d-e)), ACI 318-14: $Vc = 653502.805$
 $Mu/Vu - lw/2 = 0.00 \leq 0$
 $= 1$ (normal-weight concrete)
 $fc' = 16.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $lw = 250.00$
 $Mu = 5.1583838E-012$
 $Vu = 1.3805066E-030$
 $Nu = 27514.027$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 + Vs3 = 263893.783$
 $Vs1 = 131946.891$ is calculated for pseudo-Column 1, with:
 $d = 200.00$
 $Av = 157079.633$
 $s = 100.00$
 $fy = 420.00$
 $Vs1$ has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 131946.891 is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

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

Vs3 = 0.00 is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 420.00$$

Vs3 has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.00$$

$$V_f ((11-3)-(11.4), \text{ACI 440}) = 109599.773$$

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

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

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 a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

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

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

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

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 208.00$$

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

$$E_f = 64828.00$$

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

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 3000.00$$

End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcrws

Constant Properties

Knowledge Factor, $\gamma = 1.00$

According to 10.7.2.3, ASCE 41-17, shear walls with

transverse reinforcement percentage, $\rho_n < 0.0015$

are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17

$$\rho_n = 0.0010472$$

with $\rho_n = \rho_{s1} + \rho_{s2} + \rho_{s3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 2

$$(\text{pseudo-col.1 } \rho_{s1} = A_{s1} * b1 / s1 = (A_{s1} * h1 / s1) / A_c = 0.0005236$$

$$h1 = 250.00$$

$$s1 = 100.00$$

$$\text{total area of hoops perpendicular to shear axis, } A_{s1} = 157.0796$$

$$(\text{pseudo-col.2 } \rho_{s2} = A_{s2} * b2 / s2 = (A_{s2} * h2 / s2) / A_c = 0.0005236$$

$$h2 = 250.00$$

$$s2 = 100.00$$

$$\text{total area of hoops perpendicular to shear axis, } A_{s2} = 157.0796$$

$$(\text{grid } \rho_{s3} = A_{s3} * b3 / s3 = (A_{s3} * h3 / s3) / A_c = 0.00$$

$$h3 = 250.00$$

$$s3 = 200.00$$

$$\text{total area of hoops perpendicular to shear axis, } A_{s3} = 0.00$$

$$\text{total section area, } A_c = 750000.00$$

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$
Concrete Elasticity, $E_c = 23025.204$
Steel Elasticity, $E_s = 200000.00$
Total Height, $H_{tot} = 3000.00$
Edges Width, $W_{edg} = 250.00$
Edges Height, $H_{edg} = 600.00$
Web Width, $W_{web} = 250.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d \geq 1$)
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, $M = 2.3754821E-011$
Shear Force, $V_2 = -1.4270893E-014$
Shear Force, $V_3 = 25941.359$
Axial Force, $F = -27508.271$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{slt} = 0.00$
-Compression: $A_{slc} = 6346.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 2368.761$
-Compression: $A_{sl,com} = 2368.761$
-Middle: $A_{sl,mid} = 1608.495$
Mean Diameter of Tension Reinforcement, $DbL = 17.20$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = \phi_u = 0.0097905$
 $\phi_u = \phi_y + \phi_p = 0.0097905$

- Calculation of ϕ_y -

$\phi_y = (M_y \cdot I_p) / (E I)_{Eff} = 0.0017905$ ((10-5), ASCE 41-17))
 $M_y = 2.3485E+008$
 $(E I)_{Eff} = 0.35 \cdot E_c \cdot I$ (table 10-5)
 $E_c \cdot I = 8.9942E+013$
 $I_p = 0.5 \cdot d = 0.5 \cdot (0.8 \cdot h) = 240.00$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \min(\phi_{y_ten}, \phi_{y_com})$
 $\phi_{y_ten} = 1.3484639E-005$
with $f_y = 420.00$

$d = 208.00$
 $y = 0.25128485$
 $A = 0.01027486$
 $B = 0.00621668$
 with $pt = 0.00379609$
 $pc = 0.00379609$
 $pv = 0.00257772$
 $N = 27508.271$
 $b = 3000.00$
 $" = 0.20192308$
 $y_{comp} = 2.4018276E-005$
 with $fc^* (12.3, (ACI 440)) = 16.002$
 $fc = 16.00$
 $fl = 0.17503396$
 $b = 3000.00$
 $h = 250.00$
 $Ag = 750000.00$
 From (12.9), ACI 440: $ka = 0.00364754$
 $g = pt + pc + pv = 0.0101699$
 $rc = 40.00$
 $Ae/Ac = 0.52524587$
 Effective FRP thickness, $tf = NL * t * Cos(b1) = 1.016$
 effective strain from (12.5) and (12.12), $e_{fe} = 0.004$
 $fu = 0.01$
 $Ef = 64828.00$
 $Ec = 23025.204$
 $y = 0.25040222$
 $A = 0.0099937$
 $B = 0.00611172$
 with $Es = 200000.00$

Calculation of ratio lb/d

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

- Calculation of p -

Considering wall controlled by flexure (shear control ratio ≤ 1),
 from table 10-19: $p = 0.008$

with:

- Condition i (shear wall and wall segments)

- $(As - As') * fy + P) / (tw * lw * fc') = -0.21981824$

$As = 0.00$

$As' = 6346.017$

$fy = 420.00$

$P = 27508.271$

$tw = 3000.00$

$lw = 250.00$

$fc = 16.00$

- $V / (tw * lw * fc^{0.5}) = 5.7286610E-020$, NOTE: units in lb & in

- Confined Boundary: No

Boundary hoops spacing does not exceed $8db$ ($s1 < 8 * db$ and $s2 < 8 * db$)

Boundary Trans. Reinf. does not exceed 50% of ACI 318 provision ($Vw1 + Vw2 > 0.50 * (V - Vc - Vw3)$)

With

Boundary Element 1:

$Vw1 = 131946.891$

$s1 = 100.00$

Boundary Element 2:

$Vw2 = 131946.891$

$s2 = 100.00$

Grid Shear Force, $Vw3 = 0.00$

Concrete Shear Force, $Vc = 159686.763$

(The variables above have already been given in Shear control ratio calculation)

Mean diameter of all bars, $db = 17.33333$

Design Shear Force, $V = 1.4270893E-014$

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1
At local axis: 3
Integration Section: (b)
