

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 ($l_o/l_{ou,min} = l_b/d >= 1$)
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, $e_{fu} = 0.01$
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: $A_{sl,t} = 0.00$
-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 $V_R = *V_n = 536498.781$
From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83*fc'^{0.5}*h*d = 536498.781$

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: $V_c = 168485.214$
 $M_u/V_u - l_w/2 = 1260.184 > 0$
= 1 (normal-weight concrete)
 $fc' = 16.00$, but $fc'^{0.5} <= 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $M_u = 2.4645981E-011$
 $V_u = 1.7792573E-014$
 $N_u = 27506.85$
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)

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

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

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

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

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.

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

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

$$\text{total thickness per orientation, } t_{f1} = NL * t / \text{NoDir} = 1.016$$

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

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

$$E_f = 64828.00$$

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

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

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

$$b_w = 3000.00$$

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: 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 ($l_o/l_{ou}, \min >= 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $e_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -1.0097420E-028$
 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: $As_{,ten} = 2865.133$

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

-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 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 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:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

α_{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: $\phi_u = 0.0035$

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

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

$\phi_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$b_w = 250.00$

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

$\phi_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$b_w = 3000.00$

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

R = 40.00
Effective FRP thickness, $t_f = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\text{ase}((5.4d), \text{TBDY}) = (\text{ase}_1*A_{col1} + \text{ase}_2*A_{col2} + \text{ase}_3*A_{web})/A_{sec} = 0.00$
 $\text{ase}_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi_{2,1} = 655400.00$
 $\text{ase}_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi_{2,2} = 655400.00$
 $\text{ase}_3 = 0$ (grid does not provide confinement)
 $psh_{,min} = \text{Min}(psh_{,x}, psh_{,y}) = 0.0010472$

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}$ (column 1) = $(As_1*h_1/s_1)/Ac = 0.00125664$
 $h_1 = 600.00$
 $As_1 = Astir_1*ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,x}$ (column 2) = $(As_2*h_2/s_2)/Ac = 0.00125664$
 $h_2 = 600.00$
 $As_2 = Astir_2*ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,x}$ (web) = $(As_3*h_3/s_3)/Ac = 0.00188496$
 $h_3 = 1800.00$
 $As_3 = Astir_3*ns_3 = 0.00$
No stirups, $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}$ (column 1) = $(As_1*h_1/s_1)/Ac = 0.0005236$
 $h_1 = 250.00$
 $As_1 = Astir_1*ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,y}$ (column 2) = $(As_2*h_2/s_2)/Ac = 0.0005236$
 $h_2 = 250.00$
 $As_2 = Astir_2*ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,y}$ (web) = $(As_3*h_3/s_3)/Ac = 0.00$
 $h_3 = 250.00$
 $As_3 = Astir_3*ns_3 = 157.0796$
No stirups, $ns_3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 656.25$
 $f_{ce} = 24.00$
From ((5.A.5), 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
 $lo/lou_{,min} = lb/d = 1.00$
 $su_1 = 0.4*esu_{1,nominal}((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

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

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, 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

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

$su2 = 0.4 \cdot esu2_nominal$ ((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 $fs2 = fs = 656.25$

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

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

$suv = 0.4 \cdot esuv_nominal$ ((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 $Esv = Es = 200000.00$

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 = 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:

$$u = 1.1719585E-005$$

$$\mu = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

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

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

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

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

$$a_{se2} = 0.00$$

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

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

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

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

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

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

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.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 $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, 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 $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, 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/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: $lb/d \geq 1$

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)

$$fx = 0.00$$

$$af = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$bw = 250.00$$

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

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

 $R = 40.00$
Effective FRP thickness, $tf = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), \text{TBDY}) = (ase1*A_{col1} + ase2*A_{col2} + ase3*A_{web})/A_{sec} = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (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) = $(As1*h1/s_1)/Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1*ns1 = 157.0796$
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, $ns3 = 0.00$

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

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_{co} (5A.5, TBDY) = 0.002

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

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

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

μ_{we} ((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 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, $t_f = N L * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$\alpha_{se1} = 0.00$

$sh_{,1} = 100.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_{,2} = 100.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

$\alpha_{se3} = 0$ (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 (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/l_d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 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/l_b,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^ 2/3), from 10.3.5, ASCE 41-17.
with 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 Bisikinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

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

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

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

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

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

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

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

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.10597696$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.10597696$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.02277575$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.14087258$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.14087258$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.03027525$$

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 $Vr = Min(Vr1, Vr2) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $Vr1 = 2.4397E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $Vr1 = Vn < 0.83 * fc^{0.5} * h * d$

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: $Vc = 799137.482$

$$Mu/Vu - lw/2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

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

$$h = 250.00$$

$$d = 2400.00$$

$$lw = 3000.00$$

$$Mu = 6.1798626E-010$$

$$Vu = 1.0097420E-028$$

$$Nu = 27514.027$$

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:

$$d = 480.00$$

$$Av = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 525.00$$

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 $(\cot + \cot a)\sin a$ 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(α), 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: $\alpha = 45^\circ$

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), with:

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

dfv = d (figure 11.2, ACI 440) = 2957.00

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: Vs + Vf <= 1.9526E+006

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, Vr2 = 2.4397E+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 = 799137.482

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

= 1 (normal-weight concrete)

fc' = 24.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$\mu_u = 6.1798626E-010$$

$$\nu_u = 1.0097420E-028$$

$$N_u = 27514.027$$

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:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 525.00$$

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
 $wf/sf = 1$ (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: $\alpha = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (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: $V_s + V_f \leq 1.9526E+006$
 $bw = 250.00$

 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: 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, $f_c = f_{cm} = 16.00$
 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 ($l_o/l_{ou}, \text{min} >= 1$)
 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, $e_{fu} = 0.01$
 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 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 the static loading combination

Calculation of Mu_{1+}

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

$\mu = 0.00019036$

$Mu = 2.5476E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

α (5A.5, TBDY) = 0.002

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

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

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

μ_{we} ((5.4c), TBDY) = $\alpha s_e * s_{h,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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

$f_x = 0.00$

$\alpha f = 0.00$

$b = 250.00$

$h = 3000.00$

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

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

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), $f_{f,e} = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL*t*\text{Cos}(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
 $ase((5.4d), \text{TBDY}) = (ase1*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00$
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 $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.00$
 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
 --->
 $su (4.9) = 0.1918269$

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

Calculation of ratio l_b/l_d

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

Calculation of μ_{u1}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 0.00019626$
 $\mu_u = 3.3287E+008$

with full section properties:

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

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

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

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

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

$$a_{se1} = 0.00$$

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

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

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

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

$$a_{se2} = 0.00$$

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

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

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

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

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

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

psh,x = ps1,x+ps2,x+ps3,x = 0.00439823
ps1,x (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.A.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/lb,min = 1.00

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

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

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

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

with fs1 = fs = 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,min)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = fs = 525.00

with $E_s = E_s = 200000.00$
 $y_v = 0.0021875$
 $sh_v = 0.008$
 $ft_v = 630.00$
 $fy_v = 525.00$
 $suv = 0.032$
 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
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 525.00$
 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:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, ten / (b * d) * (fs1 / fc) = 0.14852283$
 $2 = Asl, com / (b * d) * (fs2 / fc) = 0.14852283$
 $v = Asl, mid / (b * d) * (fsv / fc) = 0.1008537$
 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: $lb/ld \geq 1$

Calculation of Mu_{2+}

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 : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$
 $ve ((5.4c), TBDY) = ase * sh, min * fywe / fce + \text{Min}(fx, fy) = 0.00$

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

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), $ffe = 636.1644$

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), $ffe = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL \cdot t \cdot \cos(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = $(ase1 \cdot Acol1 + ase2 \cdot Acol2 + ase3 \cdot Aweb) / Asec = 0.00$
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 = $\text{Min}(psh,x, psh,y) = 0.0010472$

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
Shear_factor = 1.00

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

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

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

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

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

$$\text{with } fs1 = fs = 525.00$$

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

$$y2 = 0.0021875$$

$$sh2 = 0.008$$

$$ft2 = 630.00$$

$$fy2 = 525.00$$

$$su2 = 0.032$$

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

$$\text{with } fs2 = fs = 525.00$$

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

$$yv = 0.0021875$$

$$shv = 0.008$$

$$ftv = 630.00$$

$$fyv = 525.00$$

$$suv = 0.032$$

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

$$\text{with } fsv = fs = 525.00$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.00$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 16.05417$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283$$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.00$$

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

--->

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

--->

$$s_u(4.9) = 0.1918269$$

$$M_u = M_{Rc}(4.14) = 2.5476E+008$$

$$u = s_u(4.1) = 0.00019036$$

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:

$$u = 0.00019626$$

$$M_u = 3.3287E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

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 = 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

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

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

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

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

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

$$\text{with } f_{s2} = f_s = 525.00$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0021875$$

$$sh_v = 0.008$$

$$ft_v = 630.00$$

$$fy_v = 525.00$$

$$s_{uv} = 0.032$$

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

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

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

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

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

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

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

$$\text{with } f_{sv} = f_s = 525.00$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.12455924$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.12455924$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08458134$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 16.05417$$

$$c_c (5A.5, TBDY) = 0.00203386$$

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.14852283$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.14852283$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.1008537$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.21612757$$

$$M_u = M_{Rc} (4.14) = 3.3287E+008$$

$$u = s_u (4.1) = 0.00019626$$

Calculation of ratio l_b/l_d

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

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

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

$$\text{From Table (11.5.4.6(d-e)), ACI 318-14: } V_c = 653502.805$$

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

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

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

h = 3000.00
d = 200.00
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 $(\cot + \cot a)\sin a$ 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: $\alpha = b1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = NL*t/NoDir = 1.016$

$d_{fv} = d$ (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: $V_s + V_f \leq 1.5943E+006$

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: $V_{r2} = V_n < 0.83*fc'^{0.5}*h*d$

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: $V_c = 653502.805$

$M_u/V_u - lw/2 = 0.00 \leq 0$

= 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: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ 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)

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

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

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

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), 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 <= 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, $\phi = 1.00$

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 $\rho_{s1} = A_{s1} * b1 / s1 = (A_{s1} * h1 / s1) / A_c = 0.0005236$

h1 = 250.00

s1 = 100.00

total area of hoops perpendicular to shear axis, As1 = 157.0796

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

h2 = 250.00

s2 = 100.00

total area of hoops perpendicular to shear axis, As2 = 157.0796

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

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, $f_s = f_{s_lower_bound} = 420.00$
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, $e_{fu} = 0.01$
Number of directions, $NoDir = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

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)
 $-(As - As') * f_y + P) / (t_w * l_w * f_c') = -0.21981836$
 $As = 0.00$
 $As' = 6346.017$
 $f_y = 420.00$
 $P = 27506.85$
 $t_w = 250.00$
 $l_w = 3000.00$
 $f_c = 16.00$

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 VRd

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), ACI 440) = 1.5581E+006

$f = 0.95$, for fully-wrapped sections

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

In (11.3) $\sin \theta + \cos \theta$ 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: $\theta = b1 + 90^\circ = 90.00$

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

total thickness per orientation, $tf1 = NL * t / \text{NoDir} = 1.016$

$d_{fv} = d$ (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: $V_s + V_f \leq 1.5943E+006$

$b_w = 250.00$

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

At local axis: 3

Integration Section: (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 (θ_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, $\phi = 1.00$
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 ($l_o/l_{ou,min} >= 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i = 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -1.0097420E-028$
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

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

$M_{u2+} = 6.5646E+009$, 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 κ_u according to 4.1, Biskinis/Fardis 2013:

$$\kappa_u = 1.1622708E-005$$

$$M_u = 6.5646E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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

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

$$\kappa_{ue} \text{ ((5.4c), TBDY)} = \alpha_{se} * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(\kappa_{fx}, \kappa_{fy}) = 0.00$$

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

 $\kappa_{fx} = 0.00$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

 $\kappa_{fy} = 0.00$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

 $R = 40.00$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$\alpha_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

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

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

 $p_{sh,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$

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

h1 = 600.00
As1 = Astir1*ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,x (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/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

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

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

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

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

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.10597696$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.10597696$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.00$$

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)

$v < vs, y2$ - 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 u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1719585E-005$$

$$Mu = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$fc = 24.00$$

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

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

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

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

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

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), $ff,e = 748.2496$

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, $tf = NL*t*\text{Cos}(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
 $ase((5.4d), \text{TBDY}) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$
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.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.

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 787.50$$

$$fy2 = 656.25$$

$$su2 = 0.032$$

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

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.10597696$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.10597696$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.02277575$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.14087258$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.14087258$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.03027525$$

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 l_b/l_d

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

Calculation of M_{u2+}

Calculation of ultimate curvature ϕ_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 ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$

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

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

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

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

 $\phi_{fx} = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$b_w = 250.00$

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

 $\phi_{fy} = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$b_w = 3000.00$

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

 $R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$\alpha_{se1} = 0.00$

$sh_{,1} = 100.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{,2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_{,2} = 100.00$

$bo_{,2} = 190.00$

ho_2 = 540.00
bi2_2 = 655400.00
ase3 = 0 (grid does not provide confinement)
psh,min = 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: $es_{u2_nominal} = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = fs = 656.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$fy_v = 656.25$

$s_{uv} = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$s_{uv} = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

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

with $fs_v = fs = 656.25$

with $Es_v = Es = 200000.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.10597696$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.10597696$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.00$

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 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.14087258$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.14087258$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u (4.9) = 0.06891069$

$M_u = MR_c (4.14) = 6.5646E+009$

$u = s_u (4.1) = 1.1622708E-005$

Calculation of ratio lb/d

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

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:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

c_u (5A.5, TBDY) = 0.002

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)

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

w_e ((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)

 $f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

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, $t_f = N_L * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f} = 0.015$

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

$a_{se1} = 0.00$

$sh_{1} = 100.00$

$bo_{1} = 190.00$

$ho_{1} = 540.00$

$bi_{2,1} = 655400.00$

$a_{se2} = 0.00$

$sh_{2} = 100.00$

$bo_{2} = 190.00$

$ho_{2} = 540.00$

$bi_{2,2} = 655400.00$

$a_{se3} = 0$ (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) = $(A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$$As_3 = Astir_3 * ns_3 = 157.0796$$

$$\text{No stirups, } ns_3 = 0.00$$

$$A_{sec} = 750000.00$$

$$s_1 = 100.00$$

$$s_2 = 100.00$$

$$s_3 = 200.00$$

$$fy_{we} = 656.25$$

$$f_{ce} = 24.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

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

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

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

From table 5A.1, TBDY: esu_1 nominal = 0.08,

For calculation of esu_1 nominal and y_1, sh_1, ft_1, fy_1, it is considered characteristic value fsy_1 = fs_1/1.2, from table 5.1, TBDY.

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

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

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

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

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

From table 5A.1, TBDY: esu_2 nominal = 0.08,

For calculation of esu_2 nominal and y_2, sh_2, ft_2, fy_2, it is considered characteristic value fsy_2 = fs_2/1.2, from table 5.1, TBDY.

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

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$su_v = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.10597696$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.10597696$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

f_{cc} (5A.2, TBDY) = 24.08126
 c_c (5A.5, TBDY) = 0.00203386
 c = confinement factor = 1.00339
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03027525$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

μ_u (4.9) = 0.07660732
 $M_u = M_{Rc}$ (4.14) = 7.2241E+009
 $u = \mu_u$ (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: $V_c = 799137.482$
 $M_u/V_u - l_w/2 = 0.00 \leq 0$
 = 1 (normal-weight concrete)
 $f_c' = 24.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $M_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$

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 $(\cot + \cot_a)\sin\alpha$ 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: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (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) '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: $V_c = 799137.482$
 $\mu_u / u - l_w / 2 = 0.00 \leq 0$
= 1 (normal-weight concrete)
 $f_c' = 24.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $\mu_u = 6.1798626E-010$
 $\nu_u = 1.0097420E-028$
 $N_u = 27514.027$

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) $\sin \theta + \cos \theta$ 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: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (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: $V_s + V_f \leq 1.9526E+006$
 $b_w = 250.00$

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 ($l_o/l_{ou, min} > 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i = 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 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

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 3.3287E+008$

$M_{u1+} = 2.5476E+008$, 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

$M_{u1-} = 3.3287E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 3.3287E+008$

$M_{u2+} = 2.5476E+008$, 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

$M_{u2-} = 3.3287E+008$, 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 M_{u1+}

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

$\phi_u = 0.00019036$

$M_u = 2.5476E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

α_1 (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: $\phi_u = 0.0035$

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

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

 $f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$bw = 250.00$

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

 $f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$bw = 3000.00$

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

 $R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$\alpha_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi_{2,1} = 655400.00$

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/l_d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 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

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

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

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

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

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

$$a_{se2} = 0.00$$

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

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

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

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

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

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

$$h_3 = 1800.00$$

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

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

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

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

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

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

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$$

$$h_2 = 250.00$$

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

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 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) = 0.08458134

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 Mu_{2+}

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

$u = 0.00019036$
 $Mu = 2.5476E+008$

 with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $co (5A.5, TBDY) = 0.002$
 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), $p_f = 2t_f/b_w = 0.008128$
 $b_w = 250.00$
 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 A4.4.3(6), $p_f = 2t_f/b_w = 0.00067733$
 $b_w = 3000.00$
 effective stress from (A.35), $f_{f,e} = 944.3987$

 $R = 40.00$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$

u,f = 0.015

ase ((5.4d), TBDY) = (ase1*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/l_d = 1.00

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

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

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

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

with fs1 = fs = 525.00

with Es1 = 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
 $lo/lo_{min} = lb/lb_{min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (lb/ld)^{2/3})$, 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
 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 y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 525.00$
 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:

$b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.14852283$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.14852283$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$

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 lb/ld

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

 Calculation of Mu_2 -

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

u = 0.00019626
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: $cu = 0.0035$

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

where $f = af * pf * ff_e / f_{ce}$ 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 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, $tf = NL * t * \text{Cos}(b1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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 = 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 = $0.4 \cdot esu1_nominal$ ((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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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 = $0.4 \cdot esu2_nominal$ ((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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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 = $0.4 \cdot esuv_nominal$ ((5.5), TBDY) = 0.032

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

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

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

with $fsv = fs = 525.00$

with $Esv = Es = 200000.00$

$1 = Asl,ten/(b \cdot d) \cdot (fs_1/fc) = 0.12455924$

$2 = Asl,com/(b \cdot d) \cdot (fs_2/fc) = 0.12455924$

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

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$f_{cc} (5A.2, TBDY) = 16.05417$

$cc (5A.5, TBDY) = 0.00203386$

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

$1 = Asl,ten/(b \cdot d) \cdot (fs_1/fc) = 0.14852283$

$2 = Asl,com/(b \cdot d) \cdot (fs_2/fc) = 0.14852283$

$v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.1008537$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

$v < v_{s,c}$ - 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 lb/d

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

Calculation of Shear Strength $Vr = \text{Min}(Vr_1, Vr_2) = 1.0215E+006$

Calculation of Shear Strength at edge 1, $Vr_1 = 1.0215E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $Vr_1 = Vn < 0.83 \cdot fc^{0.5} \cdot h \cdot d$

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: $Vs = Vs_1 + Vs_2 + Vs_3 = 263893.783$

$Vs_1 = 131946.891$ is calculated for pseudo-Column 1, with:

$d = 200.00$

$Av = 157079.633$

$s = 100.00$

$fy = 420.00$

Vs_1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$Vs_2 = 131946.891$ is calculated for pseudo-Column 2, with:

$d = 200.00$

$Av = 157079.633$

$s = 100.00$

$fy = 420.00$

Vs_2 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

$Vs_3 = 0.00$ is calculated for web, with:

$d = 200.00$

$Av = 0.00$

$s = 200.00$
 $f_y = 420.00$
 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 θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L * t / N_oDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 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: $V_{r2} = V_n < 0.83 * f_c'^{0.5} * h * d$

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: $V_c = 653502.805$
 $M_u / V_u - l_w / 2 = 0.00 \leq 0$
 $\lambda = 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 3000.00$
 $d = 200.00$
 $l_w = 250.00$
 $M_u = 5.1583838E-012$
 $V_u = 1.3805066E-030$
 $N_u = 27514.027$
 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 θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 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: 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 $n = ps_1 + ps_2 + ps_3$, being the shear reinf. ratio in a plane perpendicular to the shear axis 2
(pseudo-col.1 $ps_1 = A_{s1} \cdot b_1 / s_1 = (A_{s1} \cdot h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $s_1 = 100.00$
total area of hoops perpendicular to shear axis, $A_{s1} = 157.0796$
(pseudo-col.2 $ps_2 = A_{s2} \cdot b_2 / s_2 = (A_{s2} \cdot h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $s_2 = 100.00$
total area of hoops perpendicular to shear axis, $A_{s2} = 157.0796$
(grid $ps_3 = A_{s3} \cdot b_3 / s_3 = (A_{s3} \cdot h_3 / s_3) / A_c = 0.00$
 $h_3 = 250.00$
 $s_3 = 200.00$
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, $e_{fu} = 0.01$

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 $u,R = \rho \cdot u = 0.0037905$
 $u = y + p = 0.0037905$

- Calculation of y -

 $y = (M_y \cdot I_p) / (E I)_{\text{Eff}} = 0.0017905$ ((10-5), ASCE 41-17))
 $M_y = 2.3485E+008$
 $(E I)_{\text{Eff}} = 0.35 \cdot E_c \cdot I$ (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 y and M_y according to Annex 7 -

 $y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.3484638E-005$
with $f_y = 420.00$
 $d = 208.00$
 $y = 0.25128474$
 $A = 0.01027486$
 $B = 0.00621667$
with $p_t = 0.00379609$
 $p_c = 0.00379609$
 $p_v = 0.00257772$
 $N = 27506.85$
 $b = 3000.00$
 $\rho = 0.20192308$
 $y_{\text{comp}} = 2.4018281E-005$
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, $t_f = NL \cdot t \cdot \text{Cos}(\beta_1) = 1.016$

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 VRd

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, $k = 1.00$

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

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

Consequently:

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, $b_i = 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 2.4645981E-011$

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: $As_t = 0.00$

-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 ' $V_w + V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

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

$\mu_u / \mu - l_w / 2 = 1468.02 > 0$

= 1 (normal-weight concrete)

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

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 2.8343931E-011$

$\mu_u = 1.7792573E-014$

$N_u = 27506.85$

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:

$d = 200.00$

$A_v = 157079.633$

$s = 100.00$

$f_y = 420.00$

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 α 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: $\theta = 45^\circ + 90^\circ = 135^\circ$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = NL * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (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: $V_s + V_f \leq 1.5943E+006$
 $bw = 3000.00$

 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 (θ)

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

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $e_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -1.0097420E-028$

EDGE -B-

Shear Force, $V_b = 1.0097420E-028$

BOTH EDGES

Axial Force, $F = -27514.027$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 0.00$

-Compression: $A_{slc} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

(According to 10.7.2.3 $A_{sl, \text{mid}}$ 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 Mu1+

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

$$\mu = 1.1622708E-005$$

$$Mu = 6.5646E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

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

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

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

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

$$a_{se2} = 0.00$$

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

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

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

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

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

$$ps3,x \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00188496$$

$$h3 = 1800.00$$

$$As3 = Astir3 \cdot ns3 = 0.00$$

$$\text{No stirups, } ns3 = 2.00$$

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

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

$$h1 = 250.00$$

$$As1 = Astir1 \cdot ns1 = 157.0796$$

$$\text{No stirups, } ns1 = 2.00$$

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

$$h2 = 250.00$$

$$As2 = Astir2 \cdot ns2 = 157.0796$$

$$\text{No stirups, } ns2 = 2.00$$

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

$$h3 = 250.00$$

$$As3 = Astir3 \cdot ns3 = 157.0796$$

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

$$Asec = 750000.00$$

$$s_1 = 100.00$$

$$s_2 = 100.00$$

$$s_3 = 200.00$$

$$fywe = 656.25$$

$$fce = 24.00$$

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

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

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

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

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

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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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

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

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

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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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

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

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

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

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

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

γ_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = f_s = 656.25$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.10597696$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.10597696$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 24.08126$$

$$c_c (5A.5, TBDY) = 0.00203386$$

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.14087258$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.14087258$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

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_{u1} -

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

$$u = 1.1719585E-005$$

$$M_u = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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

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

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

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

$$\phi_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

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 (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

$$f_y1 = 656.25$$

$$s_u1 = 0.032$$

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

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

$$s_u1 = 0.4 * e_{s_u1,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_u1,nominal} = 0.08$,

For calculation of $e_{s_u1,nominal}$ and y_1 , sh_1, ft_1, f_y1 , it is considered
characteristic value $f_{s_y1} = f_{s_1}/1.2$, 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.

$$\text{with } f_{s_1} = f_s = 656.25$$

$$\text{with } E_{s_1} = E_s = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$f_y2 = 656.25$$

$$s_u2 = 0.032$$

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

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

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

From table 5A.1, TBDY: $e_{s_u2,nominal} = 0.08$,

For calculation of $e_{s_u2,nominal}$ and y_2 , sh_2, ft_2, f_y2 , it is considered
characteristic value $f_{s_y2} = f_{s_2}/1.2$, from table 5.1, TBDY.

y_2 , sh_2, ft_2, f_y2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_2} = f_s = 656.25$$

$$\text{with } E_{s_2} = E_s = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$f_yv = 656.25$$

$$s_{u_v} = 0.032$$

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

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

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

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

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY
For calculation of $e_{s_{u_v},nominal}$ and y_v , sh_v, ft_v, f_yv , it is considered
characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, f_y1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_v} = f_s = 656.25$$

$$\text{with } E_{s_v} = E_s = 200000.00$$

$$1 = A_{s_l,ten}/(b*d)*(f_{s_1}/f_c) = 0.10597696$$

$$2 = A_{s_l,com}/(b*d)*(f_{s_2}/f_c) = 0.10597696$$

$$v = A_{s_l,mid}/(b*d)*(f_{s_v}/f_c) = 0.02277575$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = A_{s_l,ten}/(b*d)*(f_{s_1}/f_c) = 0.14087258$$

$$2 = A_{s_l,com}/(b*d)*(f_{s_2}/f_c) = 0.14087258$$

$$v = A_{s_l,mid}/(b*d)*(f_{s_v}/f_c) = 0.03027525$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$$s_u (4.9) = 0.07660732$$

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

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

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:

$$\mu = 1.1622708E-005$$

$$\mu_{2+} = 6.5646E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

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

$$\alpha_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

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

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

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

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

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/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

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

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

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

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

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

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.10597696$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.10597696$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

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)

$v < vs,y2$ - 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:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$fc = 24.00$$

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

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

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

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

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

where $f = af * pf * ffe / fce$ 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), $pf = 2tf/bw = 0.008128$
 $bw = 250.00$
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, $tf = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), \text{TBDY}) = (ase1*A_{col1} + ase2*A_{col2} + ase3*A_{web})/A_{sec} = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (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) = $(As1*h1/s_1)/Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1*ns1 = 157.0796$
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, $ns3 = 0.00$

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

$$f_{ywe} = 656.25$$

$$f_{ce} = 24.00$$

From (5A.5), TBDY, TBDY: $cc = 0.00203386$

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

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

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

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

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

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$su_v = 0.032$$

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

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

$$su_v = 0.4 * esu_{v,nominal} ((5.5), TBDY) = 0.032$$

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

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

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

$$\text{with } f_{sv} = fs = 656.25$$

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.10597696$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.10597696$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.02277575$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.14087258$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.14087258$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.03027525$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.07660732$$

$$M_u = MR_c(4.14) = 7.2241E+009$$

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

Calculation of ratio l_b/d

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

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

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: $V_c = 799137.482$

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

= 1 (normal-weight concrete)

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

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$M_u = 6.1798626E-010$$

$$V_u = 1.0097420E-028$$

$$N_u = 27514.027$$

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) = $1.5581E+006$

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

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

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

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

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

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

$$E_f = 64828.00$$

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

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: $V_c = 799137.482$

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

= 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 $V_f(\theta, a_i)$, 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), 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: 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 ($l_o/l_{ou}, \min > 1$)

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $e_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 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

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 3.3287E+008$

$Mu_{1+} = 2.5476E+008$, 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

$Mpr2 = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.3287E+008$

$Mu_{2+} = 2.5476E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the 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 the static loading combination

Calculation of Mu_{1+}

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

$u = 0.00019036$

$Mu = 2.5476E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

α_{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) = $\alpha_{se} * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

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

 $\phi_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$b_w = 250.00$

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

$\phi_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$b_w = 3000.00$

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

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$\alpha_{se1} = 0.00$

$sh_1 = 100.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_2 = 100.00$

$bo_2 = 190.00$

$ho_2 = 540.00$

$bi_{2,2} = 655400.00$

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

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

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,min = 1.00

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

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

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

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

with fs1 = fs = 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,min)^ 2/3), from 10.3.5, ASCE 41-17.

with $f_{s2} = f_s = 525.00$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0021875$
 $sh_v = 0.008$
 $ft_v = 630.00$
 $fy_v = 525.00$
 $suv = 0.032$
 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
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = f_s = 525.00$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b * d) * (f_{s1}/f_c) = 0.12455924$
 $2 = A_{sl,com}/(b * d) * (f_{s2}/f_c) = 0.12455924$
 $v = A_{sl,mid}/(b * d) * (f_{sv}/f_c) = 0.00$

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

$su (4.9) = 0.1918269$
 $Mu = MRc (4.14) = 2.5476E+008$
 $u = su (4.1) = 0.00019036$

Calculation of ratio l_b/l_d

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

Calculation of Mu_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^* = shear_factor * $Max(cu, cc) = 0.0035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0035$

$w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$
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, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$
 $a_{se1} = 0.00$
 $sh_{,1} = 100.00$
 $bo_{,1} = 190.00$
 $ho_{,1} = 540.00$
 $bi_{2,1} = 655400.00$
 $a_{se2} = 0.00$
 $sh_{,2} = 100.00$
 $bo_{,2} = 190.00$
 $ho_{,2} = 540.00$
 $bi_{2,2} = 655400.00$
 $a_{se3} = 0$ (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, $n_{s3} = 0.00$

$A_{sec} = 750000.00$

$$s_1 = 100.00$$

$$s_2 = 100.00$$

$$s_3 = 200.00$$

$$f_{ywe} = 525.00$$

$$f_{ce} = 16.00$$

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

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

$$y_1 = 0.0021875$$

$$sh_1 = 0.008$$

$$ft_1 = 630.00$$

$$fy_1 = 525.00$$

$$su_1 = 0.032$$

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

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

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

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.

$$\text{with } fs_1 = fs = 525.00$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0021875$$

$$sh_2 = 0.008$$

$$ft_2 = 630.00$$

$$fy_2 = 525.00$$

$$su_2 = 0.032$$

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

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

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

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.

$$\text{with } fs_2 = fs = 525.00$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0021875$$

$$sh_v = 0.008$$

$$ft_v = 630.00$$

$$fy_v = 525.00$$

$$suv = 0.032$$

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

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

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

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 y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

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

$$\text{with } fsv = fs = 525.00$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.12455924$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.12455924$$

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

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 16.05417$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.14852283$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.14852283$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1008537$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

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

---->

$$s_u(4.9) = 0.21612757$$

$$M_u = M_{Rc}(4.14) = 3.3287E+008$$

$$u = s_u(4.1) = 0.00019626$$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2+}

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

$$u = 0.00019036$$

$$M_u = 2.5476E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$\phi_{fx} = 0.00$$

$$\phi_{af} = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$bw = 250.00$$

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

$$\phi_{fy} = 0.00$$

$$\phi_{af} = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$bw = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$\alpha_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi_{2,1} = 655400.00$$

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/l_d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 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 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

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

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

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

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

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

$$a_{se2} = 0.00$$

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

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

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

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

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

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

$$h_3 = 1800.00$$

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

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

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

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

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

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

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$$

$$h_2 = 250.00$$

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

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 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) = 0.08458134

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
 --->
 $su (4.9) = 0.21612757$
 $Mu = MRc (4.14) = 3.3287E+008$
 $u = su (4.1) = 0.00019626$

 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 $(\cot \theta + \csc \theta) \sin \theta$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE). This later relation, considered as a function $V_f(\theta, a_1)$, 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: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, a_1)|, |V_f(-45, a_1)|)$, 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), 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_v 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 $(\cot \theta + \csc \theta) \sin \theta$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE). This later relation, considered as a function $V_f(\theta, a_1)$, 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: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, a_1)|, |V_f(-45, a_1)|)$, 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), 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: rcrcs

Constant Properties

Knowledge Factor, $n = 1.00$
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, $Htot = 3000.00$
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 ($lb/d >= 1$)
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)
- $(As - As') * fy + P) / (tw * lw * fc') = -0.21981836$
 $As = 0.00$
 $As' = 6346.017$
 $fy = 420.00$
 $P = 27506.85$
 $tw = 250.00$
 $lw = 3000.00$
 $fc = 16.00$

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

Calculation No. 7

wall W1, Floor 1
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity VRd
Edge: End
Local Axis: (3)



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

At local axis: 3

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

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, $N_{oDir} = 1$

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: $As_c = 6346.017$
 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, $Db_{L,ten} = 17.33333$

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 ' $V_w + f \cdot V_f$ '
 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 $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

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

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

total thickness per orientation, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$

$d_{fv} = d$ (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: $V_s + V_f \leq 1.5943E+006$

$bw = 250.00$

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 (θ)

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: 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, $e_{fu} = 0.01$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -1.0097420E-028$
EDGE -B-
Shear Force, $V_b = 1.0097420E-028$
BOTH EDGES
Axial Force, $F = -27514.027$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6346.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 2865.133$
-Compression: $A_{sc,com} = 2865.133$
-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 , $V_e/V_r = 1.97404$
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 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 the static loading combination

Calculation of μ_{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:

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

$$f_c = 24.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

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

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

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

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

$$h_1 = 250.00$$

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

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

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

$$h_2 = 250.00$$

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

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

$$p_{s3,y} \text{ (web)} = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00$$

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

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

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/d

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

Calculation of M_{u1} -

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:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

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/l_d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 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.

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.10597696$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.10597696$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.02277575$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.14087258$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.14087258$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.03027525$$

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 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:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$s_{h_1} = 100.00$$

$$b_{o_1} = 190.00$$

$$h_{o_1} = 540.00$$

$$b_{i2_1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h_2} = 100.00$$

$$b_{o_2} = 190.00$$

$$h_{o_2} = 540.00$$

$$b_{i2_2} = 655400.00$$

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

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

$$h_3 = 1800.00$$

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

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

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

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

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/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 $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.10597696$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10597696$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 24.08126$$

$$c_c (5A.5, TBDY) = 0.00203386$$

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14087258$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14087258$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

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/d

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

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:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

R = 40.00
Effective FRP thickness, $t_f = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\text{ase}((5.4d), \text{TBDY}) = (\text{ase}_1*A_{col1} + \text{ase}_2*A_{col2} + \text{ase}_3*A_{web})/A_{sec} = 0.00$
 $\text{ase}_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi_{2,1} = 655400.00$
 $\text{ase}_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi_{2,2} = 655400.00$
 $\text{ase}_3 = 0$ (grid does not provide confinement)
 $psh_{,min} = \text{Min}(psh_{,x}, psh_{,y}) = 0.0010472$

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}(\text{column } 1) = (As_1*h_1/s_1)/Ac = 0.00125664$
 $h_1 = 600.00$
 $As_1 = Astir_1*ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,x}(\text{column } 2) = (As_2*h_2/s_2)/Ac = 0.00125664$
 $h_2 = 600.00$
 $As_2 = Astir_2*ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,x}(\text{web}) = (As_3*h_3/s_3)/Ac = 0.00188496$
 $h_3 = 1800.00$
 $As_3 = Astir_3*ns_3 = 0.00$
No stirups, $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}(\text{column } 1) = (As_1*h_1/s_1)/Ac = 0.0005236$
 $h_1 = 250.00$
 $As_1 = Astir_1*ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,y}(\text{column } 2) = (As_2*h_2/s_2)/Ac = 0.0005236$
 $h_2 = 250.00$
 $As_2 = Astir_2*ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,y}(\text{web}) = (As_3*h_3/s_3)/Ac = 0.00$
 $h_3 = 250.00$
 $As_3 = Astir_3*ns_3 = 157.0796$
No stirups, $ns_3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 656.25$
 $f_{ce} = 24.00$
From ((5.A.5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $su_1 = 0.032$
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
 $lo/lou_{,min} = lb/d = 1.00$
 $su_1 = 0.4*esu_{1,nominal}((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

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

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, 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 $Shear_factor = 1.00$

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

$su2 = 0.4 \cdot esu2_nominal$ ((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 $fs2 = fs = 656.25$

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 $Shear_factor = 1.00$

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

$suv = 0.4 \cdot esuv_nominal$ ((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 $Esv = Es = 200000.00$

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 = 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 $V_r = \text{Min}(V_{r1}, V_{r2}) = 2.4397\text{E}+006$

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: $V_{r1} = V_n < 0.83 \cdot f_c^{0.5} \cdot h \cdot d$

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: $V_c = 799137.482$

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

= 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 $V_f(\theta, a_i)$, 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, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (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: $V_s + V_f \leq 1.9526\text{E}+006$

$b_w = 250.00$

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: $V_{r2} = V_n < 0.83 \cdot f_c^{0.5} \cdot h \cdot d$

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: $V_c = 799137.482$

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

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

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot)\sin\alpha$ 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: $\alpha = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha)|, |V_f(-45, \alpha)|)$, 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), 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: $V_s + V_f \leq 1.9526E+006$

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: 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, Htot = 3000.00
Edges Width, Wedg = 250.00
Edges Height, Hedg = 600.00
Web Width, Wweb = 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, e_{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

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} = 0.00
-Compression: A_{slc} = 6346.017
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl, \text{ten}}$ = 2368.761
-Compression: $A_{sl, \text{com}}$ = 2368.761
-Middle: $A_{sl, \text{mid}}$ = 0.00
(According to 10.7.2.3 $A_{sl, \text{mid}}$ 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:

$$u = 0.00019036$$

$$\mu = 2.5476E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$\phi_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\phi_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

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

$$h_3 = 1800.00$$

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

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

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

 $A_{sec} = 750000.00$

$s_1 = 100.00$

$s_2 = 100.00$

$s_3 = 200.00$

$f_{ywe} = 525.00$

$f_{ce} = 16.00$

From ((5.A5), 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
Shear_factor = 1.00

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

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

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

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

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b / l_d)^{2/3})$, 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

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

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

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

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

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

with $fs_2 = fs = 525.00$

with $Es_2 = Es = 200000.00$

$y_v = 0.0021875$

$sh_v = 0.008$

$ft_v = 630.00$

$fy_v = 525.00$

$su_v = 0.032$

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

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

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

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

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

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

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

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

with $f_{sv} = f_s = 525.00$

with $E_{sv} = E_s = 200000.00$

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12455924$

$2 = A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12455924$

$v = A_{s1,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$f_{cc} (5A.2, TBDY) = 16.05417$

$cc (5A.5, TBDY) = 0.00203386$

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

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14852283$

$2 = A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14852283$

$v = A_{s1,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su (4.9) = 0.1918269$

$Mu = MRc (4.14) = 2.5476E+008$

$u = su (4.1) = 0.00019036$

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:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

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

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: $cu = 0.0035$

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

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, $tf = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), \text{TBDY}) = (ase1*A_{col1} + ase2*A_{col2} + ase3*A_{web})/A_{sec} = 0.00$
 $ase1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi2_1 = 655400.00$
 $ase2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi2_2 = 655400.00$
 $ase3 = 0$ (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) = $(As1*h1/s_1)/Ac = 0.00125664$
 $h1 = 600.00$
 $As1 = Astir1*ns1 = 157.0796$
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, $ns3 = 0.00$

 $A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 525.00$
 $f_{ce} = 16.00$
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

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

$$s_u1 = 0.4 * e_{s1_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s1_nominal} = 0.08$,

For calculation of $e_{s1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $f_{sy1} = f_s/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s1} = f_s = 525.00$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0021875$$

$$sh_2 = 0.008$$

$$ft_2 = 630.00$$

$$fy_2 = 525.00$$

$$s_u2 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$$s_u2 = 0.4 * e_{s2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s2_nominal} = 0.08$,

For calculation of $e_{s2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{sy2} = f_s/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s2} = f_s = 525.00$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0021875$$

$$sh_v = 0.008$$

$$ft_v = 630.00$$

$$fy_v = 525.00$$

$$s_{u,v} = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$$s_{u,v} = 0.4 * e_{s_{u,v}_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_{u,v}_nominal} = 0.08$,

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

For calculation of $e_{s_{u,v}_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

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

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

$$\text{with } f_{sv} = f_s = 525.00$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.12455924$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.12455924$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08458134$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 16.05417$$

$$c_c (5A.5, TBDY) = 0.00203386$$

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.14852283$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.14852283$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.1008537$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.21612757$$

$$\mu = M R_c (4.14) = 3.3287E+008$$

$$u = s_u (4.1) = 0.00019626$$

Calculation of ratio l_b/l_d

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

Calculation of μ_{2+}

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

$$\mu = 0.00019036$$

$$\mu_{2+} = 2.5476 \times 10^{-8}$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$\mu_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\mu_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi_{2,2} = 655400.00$$

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

$As_2 = Astir_2 * ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,x} (web) = (As_3 * h_3 / s_3) / Ac = 0.00188496$
 $h_3 = 1800.00$
 $As_3 = Astir_3 * ns_3 = 0.00$
No stirups, $ns_3 = 2.00$

 $psh_y = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y} (column\ 1) = (As_1 * h_1 / s_1) / Ac = 0.0005236$
 $h_1 = 250.00$
 $As_1 = Astir_1 * ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,y} (column\ 2) = (As_2 * h_2 / s_2) / Ac = 0.0005236$
 $h_2 = 250.00$
 $As_2 = Astir_2 * ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,y} (web) = (As_3 * h_3 / s_3) / Ac = 0.00$
 $h_3 = 250.00$
 $As_3 = Astir_3 * ns_3 = 157.0796$
No stirups, $ns_3 = 0.00$

 $Asec = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 525.00$
 $f_{ce} = 16.00$
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
Shear_factor = 1.00

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

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

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
Shear_factor = 1.00

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

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

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_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = fs = 525.00$

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

lo/lo_{u,min} = lb/d = 1.00

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

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

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

For calculation of esuv_nominal and γ_v, sh_v,ft_v,fy_v, it is considered characteristic value f_{sv} = f_{sv}/1.2, from table 5.1, TBDY.

γ₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(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 = Asl_{ten}/(b*d)*(f_{s1}/f_c) = 0.12455924

2 = Asl_{com}/(b*d)*(f_{s2}/f_c) = 0.12455924

v = Asl_{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 = confinement factor = 1.00339

1 = Asl_{ten}/(b*d)*(f_{s1}/f_c) = 0.14852283

2 = Asl_{com}/(b*d)*(f_{s2}/f_c) = 0.14852283

v = Asl_{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 = 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

f_c = 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}*fy_{we}/f_{ce}+Min(f_x, f_y) = 0.00

where f = af*pf*ffe/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 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 A.4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $f_{f,e} = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL*t*\text{Cos}(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
 $ase((5.4d), \text{TBDY}) = (ase1*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00$
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
 $Shear_factor = 1.00$
 $lo/lou,min = lb/l_d = 1.00$
 $su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1$, $sh1,ft1,fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1$, $sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 525.00$
 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
 $Shear_factor = 1.00$
 $lo/lou,min = lb/l_b,min = 1.00$
 $su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2$, $sh2,ft2,fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1$, $sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 525.00$
 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
 $Shear_factor = 1.00$
 $lo/lou,min = lb/l_d = 1.00$
 $suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$
 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 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 $Min(1,1.25*(lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134$
 and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < vs,c$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21612757$

$$\begin{aligned} \mu &= MRC(4.14) = 3.3287E+008 \\ u &= s_u(4.1) = 0.00019626 \end{aligned}$$

Calculation of ratio l_b/d

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

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

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: $V_c = 653502.805$

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

= 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), 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: $\theta = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \alpha)|)$, 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, $Vr2 = 1.0215E+006$
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: $Vc = 653502.805$

$Mu/Vu-lw/2 = 0.00 <= 0$

= 1 (normal-weight concrete)

$fc' = 16.00$, but $fc'^{0.5} <= 8.3$ 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 $(\cot + \cot)\sin\alpha$ which is more a generalised expression,
where α is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $Vf(\alpha)$, 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: $\alpha = b1 + 90^\circ = 90.00$

$Vf = \text{Min}(|Vf(45, \alpha)|, |Vf(-45, \alpha)|)$, 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: $Vs + Vf <= 1.5943E+006$

$bw = 3000.00$

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: (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 $\rho_n = \rho_{ps1} + \rho_{ps2} + \rho_{ps3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 2
(pseudo-col.1 $\rho_{ps1} = A_{s1} \cdot b_1 / s_1 = (A_{s1} \cdot h_1 / s_1) / A_c = 0.0005236$
 $h_1 = 250.00$
 $s_1 = 100.00$
total area of hoops perpendicular to shear axis, $A_{s1} = 157.0796$
(pseudo-col.2 $\rho_{ps2} = A_{s2} \cdot b_2 / s_2 = (A_{s2} \cdot h_2 / s_2) / A_c = 0.0005236$
 $h_2 = 250.00$
 $s_2 = 100.00$
total area of hoops perpendicular to shear axis, $A_{s2} = 157.0796$
(grid $\rho_{ps3} = A_{s3} \cdot b_3 / s_3 = (A_{s3} \cdot h_3 / s_3) / A_c = 0.00$
 $h_3 = 250.00$
 $s_3 = 200.00$
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 -

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

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$
$$y_{\text{ten}} = 1.3484638E-005$$

with $f_y = 420.00$

$$d = 208.00$$
$$y = 0.25128474$$
$$A = 0.01027486$$
$$B = 0.00621667$$

with $p_t = 0.00379609$

$$p_c = 0.00379609$$
$$p_v = 0.00257772$$
$$N = 27506.85$$
$$b = 3000.00$$
$$r = 0.20192308$$
$$y_{\text{comp}} = 2.4018281E-005$$

with $f_c^* \text{ (12.3, (ACI 440))} = 16.002$

$$f_c = 16.00$$
$$f_l = 0.17503396$$
$$b = 3000.00$$
$$h = 250.00$$
$$A_g = 750000.00$$

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, $t_f = N L * t * \text{Cos}(b_1) = 1.016$

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

$$f_u = 0.01$$
$$E_f = 64828.00$$
$$E_c = 23025.204$$
$$y = 0.25040216$$
$$A = 0.00999371$$
$$B = 0.00611172$$

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

As = 0.00

As' = 6346.017

fy = 420.00

P = 27506.85

tw = 3000.00

lw = 250.00

fc = 16.00

- $V/(tw*lw*fc^{0.5}) = 7.1423434E-020$, 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 = 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 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 ($l_o/l_{o,min} = l_b/l_d \geq 1$)

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, $N_{oDir} = 1$

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: $A_{st} = 0.00$

-Compression: $As_{lc} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle: $As_{l,mid} = 1608.495$

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

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 539417.148$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $V_n < 0.83 \cdot f_c^{0.5} \cdot h \cdot d = 539417.148$

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

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

orientation 1: $\alpha_1 = \alpha_1 + 90^\circ = 90.00$

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

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

$d_{fv} = d$ (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 (θ)

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: rcwrs

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, $e_{fu} = 0.01$
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

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: $As_{t, \text{ten}} = 2865.133$
-Compression: $As_{c, \text{com}} = 2865.133$
-Middle: $As_{c, \text{mid}} = 0.00$
(According to 10.7.2.3 $As_{c, \text{mid}}$ 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 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 the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 1.1622708E-005$

$Mu = 6.5646E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

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

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

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

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

$$a_{se2} = 0.00$$

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

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

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

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

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

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

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

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

$$h_1 = 600.00$$

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

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

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

$$h_2 = 600.00$$

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

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

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

$$h_3 = 1800.00$$

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

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

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

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

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

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

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$$

$$h_2 = 250.00$$

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

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/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/d

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

 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, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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*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 = 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 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) = $ase * sh_{,min} * fy_{we} / f_{ce} + \text{Min}(fx, fy) = 0.00$

where $f = af * pf * ff_e / f_{ce}$ 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), $ff_e = 953.7391$

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)

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

$p_{sh,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$

$ps_{1,x}$ (column 1) = $(As1 * h1 / s_1) / A_c = 0.00125664$

h1 = 600.00

$As1 = Astir1 * ns1 = 157.0796$

No stirups, ns1 = 2.00

$ps_{2,x}$ (column 2) = $(As2 * h2 / s_2) / A_c = 0.00125664$

h2 = 600.00

$As2 = Astir2 * ns2 = 157.0796$

No stirups, ns2 = 2.00

$ps_{3,x}$ (web) = $(As3 * h3 / s_3) / A_c = 0.00188496$

h3 = 1800.00

$As3 = Astir3 * ns3 = 0.00$

No stirups, ns3 = 2.00

$p_{sh,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$

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 = $0.4 \cdot esu1_nominal$ ((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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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 = $0.4 \cdot esu2_nominal$ ((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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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 = $0.4 \cdot esuv_nominal$ ((5.5), TBDY) = 0.032

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

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

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

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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:

$b = 190.00$

$d = 2927.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 24.08126$

$cc (5A.5, TBDY) = 0.00203386$

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14087258$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14087258$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

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 lb/d

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

Calculation of Mu_2 -

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

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

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

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

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, $t_f = NL * t * \cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$
 $a_{se1} = 0.00$
 $sh_{,1} = 100.00$
 $bo_{,1} = 190.00$
 $ho_{,1} = 540.00$
 $bi2_{,1} = 655400.00$
 $a_{se2} = 0.00$
 $sh_{,2} = 100.00$
 $bo_{,2} = 190.00$
 $ho_{,2} = 540.00$
 $bi2_{,2} = 655400.00$
 $a_{se3} = 0$ (grid does not provide confinement)
 $p_{sh,min} = \min(p_{sh,x}, p_{sh,y}) = 0.0010472$

$p_{sh,x} = ps1,x + ps2,x + ps3,x = 0.00439823$
 $ps1,x$ (column 1) = $(A_{s1} * h1 / s_{,1}) / A_c = 0.00125664$
 $h1 = 600.00$
 $A_{s1} = A_{stir1} * ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2,x$ (column 2) = $(A_{s2} * h2 / s_{,2}) / A_c = 0.00125664$
 $h2 = 600.00$
 $A_{s2} = A_{stir2} * ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3,x$ (web) = $(A_{s3} * h3 / s_{,3}) / A_c = 0.00188496$
 $h3 = 1800.00$
 $A_{s3} = A_{stir3} * ns3 = 0.00$
No stirups, $ns3 = 2.00$

$p_{sh,y} = ps1,y + ps2,y + ps3,y = 0.0010472$
 $ps1,y$ (column 1) = $(A_{s1} * h1 / s_{,1}) / A_c = 0.0005236$
 $h1 = 250.00$
 $A_{s1} = A_{stir1} * ns1 = 157.0796$
No stirups, $ns1 = 2.00$
 $ps2,y$ (column 2) = $(A_{s2} * h2 / s_{,2}) / A_c = 0.0005236$
 $h2 = 250.00$
 $A_{s2} = A_{stir2} * ns2 = 157.0796$
No stirups, $ns2 = 2.00$
 $ps3,y$ (web) = $(A_{s3} * h3 / s_{,3}) / A_c = 0.00$
 $h3 = 250.00$
 $A_{s3} = A_{stir3} * ns3 = 157.0796$
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
 $lo/lo_{,min} = lb/d = 1.00$

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

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

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 1.00$$

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

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_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$suv = 0.032$$

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

$$lo/lou, \text{min} = lb/ld = 1.00$$

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

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

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

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

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.10597696$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.10597696$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.14087258$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.14087258$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.03027525$$

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 lb/ld

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

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: $V_{r1} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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: $V_c = 799137.482$

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

= 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) $\sin \alpha + \cos \alpha$ is replaced with $(\cot \alpha + \csc \alpha) \sin \alpha$ which is more a generalised expression,

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

This later relation, considered as a function $V_f(\alpha, a_i)$, is implemented for every different fiber orientation a_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: $\alpha = b_1 + 90^\circ = 90.00$

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

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

$d_{fv} = d$ (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: $V_s + V_f \leq 1.9526\text{E}+006$

$b_w = 250.00$

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: $V_{r2} = V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d$

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: $V_c = 799137.482$

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

= 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

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 $V_f(\theta)$, 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, $t_{f1} = NL * t / \text{NoDir} = 1.016$

$d_{fv} = d$ (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: $V_s + V_f \leq 1.9526E+006$

$b_w = 250.00$

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 ($l_o/l_{ou,min} >= 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 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
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 3.3287E+008$
 $\mu_{u1+} = 2.5476E+008$, 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 κ_u according to 4.1, Biskinis/Fardis 2013:

$$\kappa_u = 0.00019036$$
$$M_u = 2.5476E+008$$

with full section properties:

$$b = 3000.00$$
$$d = 208.00$$
$$d' = 42.00$$
$$v = 0.00275581$$
$$N = 27514.027$$
$$f_c = 16.00$$
$$c_o \text{ (5A.5, TBDY)} = 0.002$$

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

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

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

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

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

$$\kappa_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\kappa_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

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

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

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

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 $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $e_{suv_nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 525.00$

with $E_{sv} = E_s = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12455924$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12455924$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

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 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14852283$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14852283$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

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 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 (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), $f_{fe} = 636.1644$

 $fy = 0.00$

$af = 0.00$

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, $tf = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), \text{TBDY}) = (ase1*A_{col1} + ase2*A_{col2} + ase3*A_{web})/A_{sec} = 0.00$
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) = $(As1*h1/s_1)/Ac = 0.00125664$
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: $l_b/d \geq 1$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00019036$$

$$\mu_{2+} = 2.5476 \times 10^{-8}$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, c_o) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.0035$$

$$w_e \text{ ((5.4c), TBDY)} = a_{se} * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$ps_{2,x}$ (column 2) = $(As_2 \cdot h_2 / s_2) / Ac = 0.00125664$
h2 = 600.00
As2 = Astir2 * ns2 = 157.0796
No stirups, ns2 = 2.00
 $ps_{3,x}$ (web) = $(As_3 \cdot h_3 / s_3) / Ac = 0.00188496$
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) = $(As_1 \cdot h_1 / s_1) / Ac = 0.0005236$
h1 = 250.00
As1 = Astir1 * ns1 = 157.0796
No stirups, ns1 = 2.00
ps2,y (column 2) = $(As_2 \cdot h_2 / s_2) / Ac = 0.0005236$
h2 = 250.00
As2 = Astir2 * ns2 = 157.0796
No stirups, ns2 = 2.00
ps3,y (web) = $(As_3 \cdot h_3 / s_3) / Ac = 0.00$
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.A.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/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/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 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* 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), $ff,e = 636.1644$

$f_y = 0.00$
 $a_f = 0.00$
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), $ff,e = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), \text{TBDY}) = (ase1*A_{col1} + ase2*A_{col2} + ase3*A_{web})/A_{sec} = 0.00$
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) = $(As1*h1/s_1)/Ac = 0.00125664$
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
 $f_{ywe} = 525.00$
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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 525.00$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 525.00$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.12455924$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.12455924$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.08458134$
 and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $fcc (5A.2, \text{TBDY}) = 16.05417$
 $cc (5A.5, \text{TBDY}) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.14852283$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.14852283$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.1008537$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < vs, c$ - RHS eq.(4.5) is satisfied

--->

$$\mu (4.9) = 0.21612757$$

$$M_u = M_{Rc} (4.14) = 3.3287E+008$$

$$u = \mu (4.1) = 0.00019626$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0215E+006$

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: $V_{r1} = V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d$

NOTE: In expression (22.5.1.1) 'V_w' is replaced by 'V_w + f_vV_f'
where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 653502.805$

$$M_u/V_u - l_w/2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$f_c' = 16.00, \text{ but } f_c' \cdot 0.5 \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 3000.00$$

$$d = 200.00$$

$$l_w = 250.00$$

$$M_u = 5.1583838E-012$$

$$V_u = 1.3805066E-030$$

$$N_u = 27514.027$$

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

$$f = 0.95, \text{ for fully-wrapped sections}$$

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

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: $\theta = 1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|), \text{ with:}$$

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 208.00$$

$$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$$

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.01$$

From (11-11), ACI 440: $V_s + V_f \leq 1.5943E+006$

bw = 3000.00

Calculation of Shear Strength at edge 2, 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 <= 0

= 1 (normal-weight concrete)

fc' = 16.00, but fc'^0.5 <= 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 + cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.

orientation 1: 1 = b1 + 90° = 90.00

Vf = Min(|Vf(45, 1)|, |Vf(-45,a1)|), with:

total thickness per orientation, tf1 = NL*t/NoDir = 1.016

dfv = d (figure 11.2, ACI 440) = 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 <= 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, $\rho_n < 0.0015$

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: $A_{sl,t} = 0.00$

-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, $D_{bL} = 17.33333$

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 $u_{i,R} = \mu \cdot u = 0.015$
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

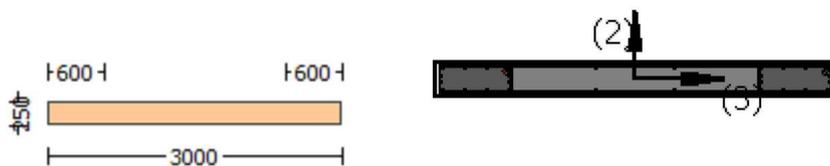
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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: 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, $N_{oDir} = 1$

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 $V_R = \gamma V_n = 1.9920E+006$

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) 'Vw' is replaced by 'Vw + fVf' where Vf 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 $(\cot + \cot\alpha)\sin\alpha$ 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: $\alpha = \alpha_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha)|, |V_f(-45, \alpha)|)$, 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 (θ_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: 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 ($l_o/l_{ou, min} > 1$)

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
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 7.2241E+009$
 $\mu_{u1+} = 6.5646E+009$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 7.2241E+009$
 $\mu_{u2+} = 6.5646E+009$, 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:

$b = 250.00$
 $d = 2957.00$
 $d' = 43.00$
 $v = 0.00155078$
 $N = 27514.027$
 $f_c = 24.00$
 $\alpha_1(5A.5, TBDY) = 0.002$
Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_{cu} = 0.0035$
 μ_{we} ((5.4c), TBDY) = $\alpha_1 * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$
where $f = \alpha_1 * \rho_f * f_{fe} / f_{ce}$ 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
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, $tf = NL*t*Cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), TBDY) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$
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
 $f_{ywe} = 656.25$
 $f_{ce} = 24.00$

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 $Esv = Es = 200000.00$

$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.10597696$

$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.10597696$

$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.00$

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)

--->

$v < v_s, y_2$ - 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 μ_1 -

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1719585E-005$$

$$M_u = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 748.2496$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 953.7391$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h_1} = 100.00$$

$$b_{o_1} = 190.00$$

$$h_{o_1} = 540.00$$

$$b_{i2_1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h_2} = 100.00$$

$$b_{o_2} = 190.00$$

$$h_{o_2} = 540.00$$

$$b_{i2_2} = 655400.00$$

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/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 $f_{s2} = f_s/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s2} = f_s = 656.25$

with $E_{s2} = E_s = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$f_{yv} = 656.25$

$s_{uv} = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/d = 1.00$

$s_{uv} = 0.4 \cdot e_{suv,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, f_{yv} , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 656.25$

with $E_{sv} = E_s = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.10597696$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.10597696$

v = $Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02277575$

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 = confinement factor = 1.00339

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14087258$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14087258$

v = $Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03027525$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.07660732$

$\mu_u = MR_c (4.14) = 7.2241E+009$

u = $s_u (4.1) = 1.1719585E-005$

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 = $1.1622708E-005$

$\mu_u = 6.5646E+009$

with full section properties:

b = 250.00

d = 2957.00

d' = 43.00

v = 0.00155078

N = 27514.027

$f_c = 24.00$

$cc (5A.5, TBDY) = 0.002$

Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} \cdot \text{Max}(c_u, cc) = 0.0035$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.0035$

w_e ((5.4c), TBDY) = $a_{se} * s_{h,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

 $f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

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, $t_f = N_L * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f} = 0.015$

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$s_{h_1} = 100.00$

$b_{o_1} = 190.00$

$h_{o_1} = 540.00$

$b_{i2_1} = 655400.00$

$a_{se2} = 0.00$

$s_{h_2} = 100.00$

$b_{o_2} = 190.00$

$h_{o_2} = 540.00$

$b_{i2_2} = 655400.00$

$a_{se3} = 0$ (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,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

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 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 < $v_{s,y2}$ - 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 lb/l_d

Adequate Lap Length: lb/l_d >= 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: $cu = 0.0035$

w_e ((5.4c), TBDY) = $ase * sh_{,min} * fy_{we}/f_{ce} + Min(f_x, f_y) = 0.00$

where $f = af * pf * f_{fe}/f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

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), $ff_e = 953.7391$

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) = $(ase1 * A_{col1} + ase2 * A_{col2} + ase3 * A_{web}) / A_{sec} = 0.00$

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

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/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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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*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 = 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 Vr = Min(Vr1,Vr2) = 2.4397E+006

Calculation of Shear Strength at edge 1, Vr1 = 2.4397E+006

From (22.5.1.1) and 11.5.4.3, ACI 318-14: Vr1 = 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 = 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)
 $h = 250.00$
 $d = 2400.00$
 $lw = 3000.00$
 $\mu_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$

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 $V_f(\theta, a_i)$, 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, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$

$d_{fv} = d$ (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: $V_s + V_f \leq 1.9526E+006$

$bw = 250.00$

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)

$h = 250.00$

$d = 2400.00$

$lw = 3000.00$

$\mu_u = 6.1798626E-010$

$V_u = 1.0097420E-028$

$N_u = 27514.027$

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:

$d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$

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 $(\cot + \cot a)\sin a$ 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(α), is implemented for every different fiber orientation ai, as well as for 2 crack directions, $\alpha = 45^\circ$ and $\alpha = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\alpha = b1 + 90^\circ = 90.00$

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), with:

total thickness per orientation, tf1 = NL*t/NoDir = 1.016

dfv = d (figure 11.2, ACI 440) = 2957.00

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 <= 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: 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, Htot = 3000.00

Edges Width, Wedg = 250.00

Edges Height, Hedg = 600.00

Web Width, Wweb = 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, $e_{fu} = 0.01$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 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: $A_{st, \text{ten}} = 2368.761$
-Compression: $A_{sc, \text{com}} = 2368.761$
-Middle: $A_{sc, \text{mid}} = 0.00$
(According to 10.7.2.3 $A_{sc, \text{mid}}$ 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 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 the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 0.00019036$
 $M_u = 2.5476E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$

$$f_c = 16.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e \text{ ((5.4c), TBDY)} = a_{se} * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N_L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.0005236$$

$$h_2 = 250.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,y} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00$$

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/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/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
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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 525.00$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0021875$$

$$shv = 0.008$$

$$ftv = 630.00$$

$$fyv = 525.00$$

$$suv = 0.032$$

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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 525.00$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 16.05417$$

$$cc (5A.5, TBDY) = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537$$

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: $lb/ld \geq 1$

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:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e \text{ ((5.4c), TBDY)} = a_{se} * s_{h,\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h_1} = 100.00$$

$$b_{o_1} = 190.00$$

$$h_{o_1} = 540.00$$

$$b_{i2_1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h_2} = 100.00$$

$$b_{o_2} = 190.00$$

$$h_{o_2} = 540.00$$

$$b_{i2_2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

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 $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.12455924$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12455924$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 16.05417$$

$$c_c (5A.5, TBDY) = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14852283$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14852283$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.1918269$$

$$M_u = M_{Rc} (4.14) = 2.5476E+008$$

$$u = s_u (4.1) = 0.00019036$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u2}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00019626$$

$$M_u = 3.3287E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

R = 40.00
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi_{2,1} = 655400.00$
 $ase_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi_{2,2} = 655400.00$
 $ase_3 = 0$ (grid does not provide confinement)
 $psh_{,min} = \min(psh_{,x}, psh_{,y}) = 0.0010472$

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / Ac = 0.00125664$
 $h_1 = 600.00$
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $ps_{2,x}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / Ac = 0.00125664$
 $h_2 = 600.00$
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
 No stirups, $ns_2 = 2.00$
 $ps_{3,x}(\text{web}) = (As_3 \cdot h_3 / s_3) / Ac = 0.00188496$
 $h_3 = 1800.00$
 $As_3 = Astir_3 \cdot ns_3 = 0.00$
 No stirups, $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / Ac = 0.0005236$
 $h_1 = 250.00$
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $ps_{2,y}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / Ac = 0.0005236$
 $h_2 = 250.00$
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
 No stirups, $ns_2 = 2.00$
 $ps_{3,y}(\text{web}) = (As_3 \cdot h_3 / s_3) / Ac = 0.00$
 $h_3 = 250.00$
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$
 No stirups, $ns_3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 525.00$
 $f_{ce} = 16.00$

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
 Shear_factor = 1.00

$lo/lou_{,min} = lb/d = 1.00$
 $su_1 = 0.4 \cdot esu_{1,nominal}((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu1_nominal$ 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 $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

$su v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$su v = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, 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 $fsv = fs = 525.00$

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) '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: $V_c = 653502.805$

$\mu_u / u - l_w / 2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 5.1583838\text{E}-012$

$V_u = 1.3805066\text{E}-030$

$N_u = 27514.027$

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) $\sin \theta + \cos \theta$ 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, $t_{f1} = NL * t / \text{NoDir} = 1.016$

$d_{fv} = d$ (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: $V_s + V_f \leq 1.5943\text{E}+006$

$b_w = 3000.00$

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) '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: $V_c = 653502.805$

$\mu_u / u - l_w / 2 = 0.00 \leq 0$

= 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: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ 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)

$2(1-s/d) = 0.00$

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 α is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(α), is implemented for every different fiber orientation a_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: $\alpha = b1 + 90^\circ = 90.00$

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), 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: $V_s + V_f \leq 1.5943E+006$

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, $\rho_n < 0.0015$

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 $\rho_{s1} = A_{s1}*b1/s1 = (A_{s1}*h1/s1) / A_c = 0.0005236$

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, $Htot = 3000.00$
 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 ($lb/ld >= 1$)
 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 -

$y = (My*lp)/(EI)Eff = 0.0017905 ((10-5), ASCE 41-17))$
 $My = 2.3485E+008$

(E_i)_{Eff} = 0.35*E_c*I (table 10-5)
E_c*I = 8.9942E+013
I_p = 0.5*d = 0.5*(0.8*h) = 240.00

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to Annex 7 -

y = Min(y_{ten}, y_{com})
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
p_c = 0.00379609
p_v = 0.00257772
N = 27508.271
b = 3000.00
" = 0.20192308
y_{comp} = 2.4018276E-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*t*Cos(β_1) = 1.016
effective strain from (12.5) and (12.12), e_{fe} = 0.004
f_u = 0.01
E_f = 64828.00
E_c = 23025.204
y = 0.25040222
A = 0.0099937
B = 0.00611172
with E_s = 200000.00

Calculation of ratio I_b/I_d

Adequate Lap Length: I_b/I_d >= 1

- Calculation of ρ_p -

Considering wall controlled by flexure (shear control ratio <= 1),
from table 10-19: ρ_p = 0.008

with:

- Condition i (shear wall and wall segments)

- (A_s-A_{s'})*f_y+P)/(t_w*I_w*f_{c'}) = -0.21981824

A_s = 0.00

A_{s'} = 6346.017

f_y = 420.00

P = 27508.271

t_w = 3000.00

I_w = 250.00

f_c = 16.00

- V/(t_w*I_w*f_c^{0.5}) = 5.7286610E-020, NOTE: units in I_b & 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 ($V_{w1} + V_{w2} > 0.50*(V-V_c-V_{w3})$)

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

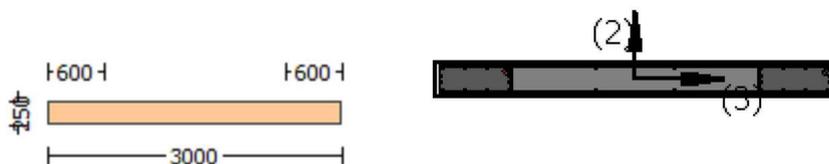
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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, $e_{fu} = 0.01$
 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, $M_a = 1.8746810E-011$
 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) 'Vw' is replaced by 'Vw+ $\phi \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

From Table (11.5.4.6(d-e)), ACI 318-14: $V_c = 159686.763$
 $M_u/V_u - l_w/2 = 1539.564 > 0$
 = 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), ACI 440) = 109599.773

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) $\sin \alpha + \cos \alpha$ is replaced with $(\cot \alpha + \cot \alpha) \sin \alpha$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\alpha, a_1)$, is implemented for every different fiber orientation a_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: $\alpha = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, a_1)|, |V_f(-45, a_1)|)$, 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), 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: (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 (θ)

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
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 7.2241E+009$
 $\mu_{u1+} = 6.5646E+009$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 7.2241E+009$
 $\mu_{u2+} = 6.5646E+009$, 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
fc = 24.00
co (5A.5, TBDY) = 0.002
Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.0035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_{cu} = 0.0035$
 μ_{we} ((5.4c), TBDY) = $a_{se} * \text{sh}_{,\text{min}} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$
where $f = a_f * \rho_f * f_{fe}/f_{ce}$ 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), $pf = 2tf/bw = 0.008128$
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, $tf = NL*t*Cos(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u,f = 0.015$
 $ase((5.4d), TBDY) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$
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
 $f_{ywe} = 656.25$
 $f_{ce} = 24.00$

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 l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of M_{u1} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1719585E-005$$

$$M_u = 7.2241E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 748.2496$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 953.7391$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi_{2,2} = 655400.00$$

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.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*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 $f_{s2} = f_s/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s2} = f_s = 656.25$

with $E_{s2} = E_s = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$f_{y_v} = 656.25$

$s_{u_v} = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/d = 1.00$

$s_{u_v} = 0.4 \cdot e_{s_{u_v,nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $e_{s_{u_v,nominal}} = 0.08$,

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY

For calculation of $e_{s_{u_v,nominal}}$ and y_v, sh_v, ft_v, f_{y_v} , it is considered

characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s_v} = f_s = 656.25$

with $E_{s_v} = E_s = 200000.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.10597696$

2 = $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.10597696$

$v = As_{l,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.02277575$

and confined core properties:

$b = 190.00$

$d = 2927.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 24.08126$

$cc (5A.5, TBDY) = 0.00203386$

$c =$ confinement factor = 1.00339

1 = $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.14087258$

2 = $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.14087258$

$v = As_{l,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.03027525$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.07660732$

$\mu_u = MR_c (4.14) = 7.2241E+009$

$u = s_u (4.1) = 1.1719585E-005$

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:

$u = 1.1622708E-005$

$\mu_u = 6.5646E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

$cc (5A.5, TBDY) = 0.002$

Final value of c_u : $c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, cc) = 0.0035$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.0035$

w_e ((5.4c), TBDY) = $a_{se} * s_{h,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

 $f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

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, $t_f = N_L * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f} = 0.015$

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$s_{h_1} = 100.00$

$b_{o_1} = 190.00$

$h_{o_1} = 540.00$

$b_{i2_1} = 655400.00$

$a_{se2} = 0.00$

$s_{h_2} = 100.00$

$b_{o_2} = 190.00$

$h_{o_2} = 540.00$

$b_{i2_2} = 655400.00$

$a_{se3} = 0$ (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,min = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = fs = 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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/lb,min = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 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 < $v_{s,y2}$ - 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 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) = $ase * sh_{min} * fy_{we}/f_{ce} + Min(f_x, f_y) = 0.00$

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 A.4.4.3(6), $pf = 2tf/bw = 0.008128$

bw = 250.00

effective stress from (A.35), $ff_e = 748.2496$

 $f_y = 0.00$

$af = 0.00$

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, $tf = NL * t * Cos(b1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

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/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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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*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 = 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 Vr = Min(Vr1,Vr2) = 2.4397E+006

Calculation of Shear Strength at edge 1, Vr1 = 2.4397E+006

From (22.5.1.1) and 11.5.4.3, ACI 318-14: Vr1 = 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 = 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)
 $h = 250.00$
 $d = 2400.00$
 $lw = 3000.00$
 $\mu_u = 6.1798626E-010$
 $V_u = 1.0097420E-028$
 $N_u = 27514.027$

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 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 a_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: $\alpha = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha)|, |V_f(-45, \alpha)|)$, 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) 'Vw' is replaced by 'Vw + f*Vf' 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)

$h = 250.00$

$d = 2400.00$

$lw = 3000.00$

$\mu_u = 6.1798626E-010$

$V_u = 1.0097420E-028$

$N_u = 27514.027$

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:

$d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$

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 $(\cot + \cot a)\sin a$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $Vf(\alpha, a)$, is implemented for every different fiber orientation a_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: $\alpha = b1 + 90^\circ = 90.00$

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), with:

total thickness per orientation, $tf1 = NL*t/NoDir = 1.016$

dfv = d (figure 11.2, ACI 440) = 2957.00

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 <= 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: 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 ($l_o/l_{ou, \min} >= 1$)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 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: $A_{st, \text{ten}} = 2368.761$
-Compression: $A_{sc, \text{com}} = 2368.761$
-Middle: $A_{sc, \text{mid}} = 0.00$
(According to 10.7.2.3 $A_{sc, \text{mid}}$ 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 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 the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 0.00019036$
 $M_u = 2.5476E+008$

with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$

$$f_c = 16.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e \text{ ((5.4c), TBDY)} = a_{se} * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N_L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_{,2} = 100.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_{,1}) / A_c = 0.0005236$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_{,2}) / A_c = 0.0005236$$

$$h_2 = 250.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,y} \text{ (web)} = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00$$

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/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

$d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 16.05417$
 $cc (5A.5, TBDY) = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14852283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14852283$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->
 $su (4.9) = 0.1918269$
 $Mu = MRc (4.14) = 2.5476E+008$
 $u = su (4.1) = 0.00019036$

 Calculation of ratio l_b/d

 Adequate Lap Length: $l_b/d \geq 1$

 Calculation of $Mu1$ -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 0.00019626$
 $Mu = 3.3287E+008$

 with full section properties:

$b = 3000.00$
 $d = 208.00$
 $d' = 42.00$
 $v = 0.00275581$
 $N = 27514.027$
 $f_c = 16.00$
 $co (5A.5, TBDY) = 0.002$
 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), $p_f = 2t_f/b_w = 0.008128$
 $b_w = 250.00$
 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), $p_f = 2t_f/b_w = 0.00067733$
 $b_w = 3000.00$
 effective stress from (A.35), $f_{f,e} = 944.3987$

 $R = 40.00$
 Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

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 = 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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 525.00$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0021875$$

$$shv = 0.008$$

$$ftv = 630.00$$

$$fyv = 525.00$$

$$suv = 0.032$$

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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 525.00$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.12455924$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12455924$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.08458134$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 16.05417$$

$$cc (5A.5, TBDY) = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.14852283$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.14852283$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.1008537$$

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: $lb/ld \geq 1$

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:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e \text{ ((5.4c), TBDY)} = a_{se} * s_{h,\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h,1} = 100.00$$

$$b_{o,1} = 190.00$$

$$h_{o,1} = 540.00$$

$$b_{i2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h,2} = 100.00$$

$$b_{o,2} = 190.00$$

$$h_{o,2} = 540.00$$

$$b_{i2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.0010472$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.0005236$$

$$h_1 = 250.00$$

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 $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.12455924$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12455924$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 16.05417$$

$$c_c (5A.5, TBDY) = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.14852283$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14852283$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.1918269$$

$$M_u = M_{Rc} (4.14) = 2.5476E+008$$

$$u = s_u (4.1) = 0.00019036$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u2}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00019626$$

$$M_u = 3.3287E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0035$$

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

R = 40.00
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$
 $ase_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi_{2,1} = 655400.00$
 $ase_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi_{2,2} = 655400.00$
 $ase_3 = 0$ (grid does not provide confinement)
 $psh_{,min} = \min(psh_{,x}, psh_{,y}) = 0.0010472$

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / Ac = 0.00125664$
 $h_1 = 600.00$
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $ps_{2,x}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / Ac = 0.00125664$
 $h_2 = 600.00$
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
 No stirups, $ns_2 = 2.00$
 $ps_{3,x}(\text{web}) = (As_3 \cdot h_3 / s_3) / Ac = 0.00188496$
 $h_3 = 1800.00$
 $As_3 = Astir_3 \cdot ns_3 = 0.00$
 No stirups, $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / Ac = 0.0005236$
 $h_1 = 250.00$
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $ps_{2,y}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / Ac = 0.0005236$
 $h_2 = 250.00$
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$
 No stirups, $ns_2 = 2.00$
 $ps_{3,y}(\text{web}) = (As_3 \cdot h_3 / s_3) / Ac = 0.00$
 $h_3 = 250.00$
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$
 No stirups, $ns_3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $f_{ywe} = 525.00$
 $f_{ce} = 16.00$
 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
 Shear_factor = 1.00
 $lo/lou_{,min} = lb/d = 1.00$
 $su_1 = 0.4 \cdot esu_{1,nominal}((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu1_nominal$ 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 $Es2 = Es = 200000.00$

$yv = 0.0021875$

$shv = 0.008$

$ftv = 630.00$

$fyv = 525.00$

$su v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$ and also multiplied by the $shear_factor$ according to 15.7.1.4, with $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$su v = 0.4 \cdot esuv_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, 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 = 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) '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: $V_c = 653502.805$

$\mu_u / \mu - l_w / 2 = 0.00 \leq 0$

= 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 $V_f(\theta)$, 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) = 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) '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: $V_c = 653502.805$

$\mu_u / \mu - l_w / 2 = 0.00 \leq 0$

= 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)

$2(1-s/d) = 0.00$

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 α is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(α), is implemented for every different fiber orientation a_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: $\alpha = b1 + 90^\circ = 90.00$

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), 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: $V_s + V_f \leq 1.5943E+006$

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, $\gamma < 0.0015$

are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17

$\gamma = 0.0010472$

with $\gamma = \rho_{s1} + \rho_{s2} + \rho_{s3}$, being the shear reinf. ratio in a plane perpendicular to the shear axis 3

(pseudo-col.1 $\rho_{s1} = A_{s1}*b1/s1 = (A_{s1}*h1/s1) / A_c = 0.0005236$

h1 = 250.00

s1 = 100.00

total area of hoops perpendicular to shear axis, $A_{s1} = 157.0796$
(pseudo-col.2 $ps2 = A_{s2} * b2 / s2 = (A_{s2} * h2 / s2) / A_c = 0.0005236$
 $h2 = 250.00$
 $s2 = 100.00$
total area of hoops perpendicular to shear axis, $A_{s2} = 157.0796$
(grid $ps3 = A_{s3} * b3 / s3 = (A_{s3} * h3 / s3) / A_c = 0.00$
 $h3 = 250.00$
 $s3 = 200.00$
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 ($l_b / l_d > 1$)
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

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, $DbL = 17.33333$

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 $u_{,R} = * u = 0.015$
from table 10-20: $u = 0.015$

with:

- Condition i (shear wall and wall segments)
- $(A_s - A_{s'}) * f_y + P) / (t_w * l_w * f_c') = -0.21981824$
 $A_s = 0.00$
 $A_{s'} = 6346.017$
 $f_y = 420.00$
 $P = 27508.271$

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: rcwsw

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, 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 ($l_o/l_{o,min} = l_b/l_d \geq 1$)
 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, 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: $V_n < 0.83 \cdot f_c' \cdot 0.5 \cdot h \cdot d = 1.9920E+006$

 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: $V_c = 653501.654$
 $\mu_u/V_u - l_w/2 = -1499.928 \leq 0$
 = 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $h = 250.00$
 $d = 2400.00$
 $l_w = 3000.00$
 $\mu_u = 1864.942$
 $V_u = 25941.359$
 $N_u = 27508.271$
 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:
 $d = 480.00$
 $A_v = 157079.633$
 $s = 100.00$

$$f_y = 420.00$$

Vs1 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs2 = 316672.539 is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 420.00$$

Vs2 has been multiplied by 1 ($s < d/2$, according to ASCE 41-17,10.3.4)

Vs3 = 475008.809 is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 420.00$$

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 $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = 45^\circ + 90^\circ = 135^\circ$

$V_f = \text{Min}(|V_f(45, a)|, |V_f(-45, a)|)$, 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), 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: $V_s + V_f \leq 1.5943E+006$

$$b_w = 250.00$$

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: 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 ($l_o/l_{ou}, \min >= 1$)
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $e_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -1.0097420E-028$
 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: $As_{,ten} = 2865.133$

-Compression: $As_{,com} = 2865.133$

-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 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 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:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00155078$

$N = 27514.027$

$f_c = 24.00$

α_{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: $\phi_u = 0.0035$

ω_{we} ((5.4c), TBDY) = $\alpha_{se} * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where $\phi = \alpha_{se} * \text{pf} * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.00$

$\alpha_{se} = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $\text{pf} = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35), $f_{fe} = 748.2496$

$\phi_y = 0.00$

$\alpha_{se} = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $\text{pf} = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35), $f_{fe} = 953.7391$

R = 40.00
Effective FRP thickness, $t_f = NL*t*\text{Cos}(b1) = 1.016$
 $f_{u,f} = 1055.00$
 $E_f = 64828.00$
 $u_{,f} = 0.015$
 $\text{ase}((5.4d), \text{TBDY}) = (\text{ase}_1*A_{col1} + \text{ase}_2*A_{col2} + \text{ase}_3*A_{web})/A_{sec} = 0.00$
 $\text{ase}_1 = 0.00$
 $sh_1 = 100.00$
 $bo_1 = 190.00$
 $ho_1 = 540.00$
 $bi_{2,1} = 655400.00$
 $\text{ase}_2 = 0.00$
 $sh_2 = 100.00$
 $bo_2 = 190.00$
 $ho_2 = 540.00$
 $bi_{2,2} = 655400.00$
 $\text{ase}_3 = 0$ (grid does not provide confinement)
 $psh_{,min} = \text{Min}(psh_{,x}, psh_{,y}) = 0.0010472$

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00439823$
 $ps_{1,x}(\text{column } 1) = (As_1*h_1/s_1)/Ac = 0.00125664$
 $h_1 = 600.00$
 $As_1 = Astir_1*ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,x}(\text{column } 2) = (As_2*h_2/s_2)/Ac = 0.00125664$
 $h_2 = 600.00$
 $As_2 = Astir_2*ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,x}(\text{web}) = (As_3*h_3/s_3)/Ac = 0.00188496$
 $h_3 = 1800.00$
 $As_3 = Astir_3*ns_3 = 0.00$
No stirups, $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.0010472$
 $ps_{1,y}(\text{column } 1) = (As_1*h_1/s_1)/Ac = 0.0005236$
 $h_1 = 250.00$
 $As_1 = Astir_1*ns_1 = 157.0796$
No stirups, $ns_1 = 2.00$
 $ps_{2,y}(\text{column } 2) = (As_2*h_2/s_2)/Ac = 0.0005236$
 $h_2 = 250.00$
 $As_2 = Astir_2*ns_2 = 157.0796$
No stirups, $ns_2 = 2.00$
 $ps_{3,y}(\text{web}) = (As_3*h_3/s_3)/Ac = 0.00$
 $h_3 = 250.00$
 $As_3 = Astir_3*ns_3 = 157.0796$
No stirups, $ns_3 = 0.00$

$A_{sec} = 750000.00$
 $s_1 = 100.00$
 $s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 656.25$
 $f_{ce} = 24.00$
From ((5.A.5), TBDY), TBDY: $cc = 0.00203386$
 $c = \text{confinement factor} = 1.00339$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $su_1 = 0.032$
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
 $lo/lou_{,min} = lb/d = 1.00$
 $su_1 = 0.4*esu_{1,nominal}((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, 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 $Shear_factor = 1.00$

$lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$

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 $fs2 = fs = 656.25$

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 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$

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:

$b = 190.00$

$d = 2927.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 24.08126$

$cc (5A.5, TBDY) = 0.00203386$

c = 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:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00155078$$

$$N = 27514.027$$

$$f_c = 24.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.0035$$

$$\mu_{we} \text{ ((5.4c), TBDY)} = a_{se} * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where $f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 748.2496$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 953.7391$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi_{2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00439823$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00125664$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

No stirups, $n_{s1} = 2.00$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00125664$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

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.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 $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, 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 $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, 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/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: $lb/d \geq 1$

Calculation of Mu_{2+}

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)

$$fx = 0.00$$

$$af = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2tf/bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } ffe = 748.2496$$

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/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

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_{co} (5A.5, TBDY) = 0.002

Final value of μ_c : $\mu_c^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.0035$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_c = 0.0035$

μ_{we} ((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 A.4.4.3(6), $p_f = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35), $f_{f,e} = 748.2496$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6), $p_f = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35), $f_{f,e} = 953.7391$

$R = 40.00$

Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

α_{se} ((5.4d), TBDY) = $(\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_{,1} = 100.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_{,2} = 100.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

$\alpha_{se3} = 0$ (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 (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/l_d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 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/l_b,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/l_d)^ 2/3), from 10.3.5, ASCE 41-17.
with 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 Bisikinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv , shv , ftv , fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.10597696$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.10597696$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.02277575$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 24.08126$$

$$cc (5A.5, TBDY) = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.14087258$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.14087258$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.03027525$$

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 $Vr = Min(Vr1, Vr2) = 2.4397E+006$

Calculation of Shear Strength at edge 1, $Vr1 = 2.4397E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14: $Vr1 = Vn < 0.83 * fc^{0.5} * h * d$

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: $Vc = 799137.482$

$$Mu/Vu - lw/2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$fc' = 24.00, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 250.00$$

$$d = 2400.00$$

$$lw = 3000.00$$

$$Mu = 6.1798626E-010$$

$$Vu = 1.0097420E-028$$

$$Nu = 27514.027$$

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:

$$d = 480.00$$

$$Av = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 525.00$$

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 $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = 45^\circ$

Vf = Min(|Vf(45, θ)|, |Vf(-45, θ)|), with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

dfv = d (figure 11.2, ACI 440) = 2957.00

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: $V_s + V_f \leq 1.9526E+006$

$$b_w = 250.00$$

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) '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: $V_c = 799137.482$

$$\mu_u / \nu_u - l_w / 2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$f_c' = 24.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$\mu_u = 6.1798626E-010$$

$$\nu_u = 1.0097420E-028$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} + V_{s3} = 1.3854E+006$

Vs1 = 395840.674 is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 100.00$$

$$f_y = 525.00$$

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:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 525.00$$

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 $(\cot + \cot\alpha)\sin\alpha$ 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: $\alpha = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = NL * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (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: 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, $f_c = f_{cm} = 16.00$
 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 ($l_o/l_{ou}, \text{min} >= 1$)
 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, $e_{fu} = 0.01$
 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

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 3.3287E+008$

$\mu_{u1+} = 2.5476E+008$, 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:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

α (5A.5, TBDY) = 0.002

Final value of μ_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)

From (5.4b), TBDY: $\mu_u = 0.0035$

μ_{we} ((5.4c), TBDY) = $\alpha s_e * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where $f = \alpha f_p * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$\alpha f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6), $\text{pf} = 2t_f/b_w = 0.008128$

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 A.4.4.3(6), $pf = 2tf/bw = 0.00067733$
bw = 3000.00
effective stress from (A.35), $f_{f,e} = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL*t*\text{Cos}(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
 $ase((5.4d), \text{TBDY}) = (ase1*Acol1+ase2*Acol2+ase3*Aweb)/Asec = 0.00$
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

$$lo/lou,min = lb/l_d = 1.00$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 525.00$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0021875$$

$$sh2 = 0.008$$

$$ft2 = 630.00$$

$$fy2 = 525.00$$

$$su2 = 0.032$$

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

$$lo/lou,min = lb/l_{b,min} = 1.00$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 525.00$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0021875$$

$$shv = 0.008$$

$$ftv = 630.00$$

$$fyv = 525.00$$

$$suv = 0.032$$

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

$$lo/lou,min = lb/l_d = 1.00$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

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 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.

$$\text{with } fsv = fs = 525.00$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.12455924$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.12455924$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 16.05417$$

$$cc (5A.5, TBDY) = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.14852283$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.14852283$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.1918269$$

$$\begin{aligned} \text{Mu} &= \text{MRc} (4.14) = 2.5476\text{E}+008 \\ u &= \text{su} (4.1) = 0.00019036 \end{aligned}$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_1 -

Calculation of ultimate curvature κ_u according to 4.1, Biskinis/Fardis 2013:
 $\kappa_u = 0.00019626$
 $\text{Mu} = 3.3287\text{E}+008$

with full section properties:

$$\begin{aligned} b &= 3000.00 \\ d &= 208.00 \\ d' &= 42.00 \\ v &= 0.00275581 \\ N &= 27514.027 \\ f_c &= 16.00 \end{aligned}$$

$$c_o (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \kappa_u: \kappa_u^* = \text{shear_factor} * \text{Max}(\kappa_u, \kappa_c) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \kappa_u = 0.0035$$

$$\kappa_{we} ((5.4c), \text{TBDY}) = a_{se} * \text{sh}_{,\min} * f_{ywe} / f_{ce} + \text{Min}(\kappa_{fx}, \kappa_{fy}) = 0.00$$

where $\kappa_f = a_f * p_f * f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\kappa_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$\kappa_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 100.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 100.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.0010472$$

ps_{1,x} = ps_{1,x}+ps_{2,x}+ps_{3,x} = 0.00439823
ps_{1,x} (column 1) = (As₁*h₁/s₁)/Ac = 0.00125664
h₁ = 600.00
As₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
ps_{2,x} (column 2) = (As₂*h₂/s₂)/Ac = 0.00125664
h₂ = 600.00
As₂ = Astir₂*ns₂ = 157.0796
No stirups, ns₂ = 2.00
ps_{3,x} (web) = (As₃*h₃/s₃)/Ac = 0.00188496
h₃ = 1800.00
As₃ = Astir₃*ns₃ = 0.00
No stirups, ns₃ = 2.00

ps_{1,y} = ps_{1,y}+ps_{2,y}+ps_{3,y} = 0.0010472
ps_{1,y} (column 1) = (As₁*h₁/s₁)/Ac = 0.0005236
h₁ = 250.00
As₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
ps_{2,y} (column 2) = (As₂*h₂/s₂)/Ac = 0.0005236
h₂ = 250.00
As₂ = Astir₂*ns₂ = 157.0796
No stirups, ns₂ = 2.00
ps_{3,y} (web) = (As₃*h₃/s₃)/Ac = 0.00
h₃ = 250.00
As₃ = Astir₃*ns₃ = 157.0796
No stirups, ns₃ = 0.00

Asec = 750000.00
s₁ = 100.00
s₂ = 100.00
s₃ = 200.00
fywe = 525.00
fce = 16.00

From ((5.A.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/l_d = 1.00

su₁ = 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 y₁, sh₁,ft₁,fy₁, it is considered
characteristic value fsy₁ = fs₁/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₁ = fs = 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/l_{b,min} = 1.00

su₂ = 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 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/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = fs = 525.00

with $E_s = E_s = 200000.00$
 $y_v = 0.0021875$
 $sh_v = 0.008$
 $ft_v = 630.00$
 $fy_v = 525.00$
 $suv = 0.032$
 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
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 525.00$
 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: $lb/ld \geq 1$

Calculation of Mu_{2+}

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: $cu = 0.0035$
 $ve ((5.4c), TBDY) = ase * sh,min * fywe / fce + Min(fx, fy) = 0.00$

where $f = af \cdot pf \cdot ffe / fce$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

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), $ffe = 636.1644$

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), $ffe = 944.3987$

R = 40.00
Effective FRP thickness, $tf = NL \cdot t \cdot \cos(b1) = 1.016$
fu,f = 1055.00
Ef = 64828.00
u,f = 0.015
ase ((5.4d), TBDY) = $(ase1 \cdot Acol1 + ase2 \cdot Acol2 + ase3 \cdot Aweb) / Asec = 0.00$
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 = $\text{Min}(psh,x, psh,y) = 0.0010472$

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

$s_2 = 100.00$
 $s_3 = 200.00$
 $fy_{we} = 525.00$
 $f_{ce} = 16.00$
 From ((5.A5), 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 1.00$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = fs = 525.00$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 525.00$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 1.00$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 525.00$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.12455924$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.12455924$
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.00$
 and confined core properties:
 $b = 2940.00$
 $d = 178.00$
 $d' = 12.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 16.05417$
 $cc \text{ (5A.5, TBDY)} = 0.00203386$
 $c = \text{confinement factor} = 1.00339$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.14852283$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.14852283$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.1918269$$

$$M_u = M_{Rc}(4.14) = 2.5476E+008$$

$$u = s_u(4.1) = 0.00019036$$

Calculation of ratio l_b / l_d

Adequate Lap Length: $l_b / l_d \geq 1$

Calculation of M_{u2}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00019626$$

$$M_u = 3.3287E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$\omega(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0035$$

$$\omega_e(5.4c, TBDY) = a_{se} \cdot \text{sh}_{, \min} \cdot f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$$

where $\phi_f = a_f \cdot p_f \cdot f_{fe} / f_{ce}$ is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\phi_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L^* t \text{Cos}(\beta_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_{,1} = 100.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$a_{se2} = 0.00$$

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 = 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

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,

For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = f_s = 525.00$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0021875$$

$$sh_v = 0.008$$

$$ft_v = 630.00$$

$$fy_v = 525.00$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = f_s = 525.00$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.12455924$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.12455924$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08458134$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 16.05417$$

$$c_c (5A.5, TBDY) = 0.00203386$$

$$c = \text{confinement factor} = 1.00339$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.14852283$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.14852283$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.1008537$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.21612757$$

$$M_u = M_{Rc} (4.14) = 3.3287E+008$$

$$u = s_u (4.1) = 0.00019626$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0215E+006$

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_vV_f' where V_f is the contribution of FRPs (11.3), ACI 440).

$$\text{From Table (11.5.4.6(d-e)), ACI 318-14: } V_c = 653502.805$$

$$M_u/V_u - l_w/2 = 0.00 \leq 0$$

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 16.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

h = 3000.00
d = 200.00
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)

$2(1-s/d) = 0.00$

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 α is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(α), 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: $\alpha = b1 + 90^\circ = 90.00$

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), 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: $V_s + V_f \leq 1.5943E+006$

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: $V_{r2} = V_n < 0.83*fc'^{0.5}*h*d$

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: $V_c = 653502.805$

$Mu/V_u - lw/2 = 0.00 \leq 0$

= 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: $V_s = V_{s1} + V_{s2} + V_{s3} = 263893.783$

$V_{s1} = 131946.891$ 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)

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 α is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(α), is implemented for every different fiber orientation ai, as well as for 2 crack directions, $\alpha = 45^\circ$ and $\alpha = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\alpha = b1 + 90^\circ = 90.00$

Vf = Min(|Vf(45, α)|, |Vf(-45, α)|), 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 <= 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: (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 $\rho_{s1} = A_{s1} * b1 / s1 = (A_{s1} * h1 / s1) / A_c = 0.0005236$

h1 = 250.00

s1 = 100.00

total area of hoops perpendicular to shear axis, As1 = 157.0796

(pseudo-col.2 $\rho_{s2} = A_{s2} * b2 / s2 = (A_{s2} * h2 / s2) / A_c = 0.0005236$

h2 = 250.00

s2 = 100.00

total area of hoops perpendicular to shear axis, As2 = 157.0796

(grid $\rho_{s3} = A_{s3} * b3 / s3 = (A_{s3} * h3 / s3) / A_c = 0.00$

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, $f_s = f_{s_lower_bound} = 420.00$
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, $e_{fu} = 0.01$
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

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: $A_{st} = 0.00$
-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: $A_{st,mid} = 1608.495$
Mean Diameter of Tension Reinforcement, $DbL = 17.20$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\theta_{u,R} = \theta_u = 0.0097905$
 $\theta_u = \theta_y + \theta_p = 0.0097905$

- Calculation of θ_y -

$\theta_y = (M_y \cdot I_p) / (EI)_{Eff} = 0.0017905$ ((10-5), ASCE 41-17))
 $M_y = 2.3485E+008$
 $(EI)_{Eff} = 0.35 \cdot E_c \cdot I$ (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 θ_y and M_y according to Annex 7 -

$\theta_y = \text{Min}(\theta_{y_ten}, \theta_{y_com})$
 $\theta_{y_ten} = 1.3484639E-005$
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), efe = 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 >= 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)

- $(A_s - A_s') * f_y + P) / (t_w * l_w * f_c') = -0.21981824$

As = 0.00

As' = 6346.017

fy = 420.00

P = 27508.271

tw = 3000.00

lw = 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 (s1 < 8*db and s2 < 8*db)

Boundary Trans. Reinf. does not exceed 50% of ACI 318 provision ($V_w1 + V_w2 > 0.50 * (V - V_c - V_w3)$)

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)
