

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

wall W1, Floor 1

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

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrws

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$   
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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = l_b = 300.00$   
FRP Wrapping Data  
Type: Carbon  
Cured laminate properties (design values)  
Thickness,  $t = 1.016$   
Tensile Strength,  $f_f = 1055.00$   
Tensile Modulus,  $E_f = 64828.00$   
Elongation,  $e_f = 0.01$   
Number of directions,  $N_{oDir} = 1$   
Fiber orientations,  $b_i = 0.00^\circ$   
Number of layers,  $N_L = 1$   
Radius of rounding corners,  $R = 40.00$

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Stepwise Properties  
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EDGE -A-  
Bending Moment,  $M_a = -9.6691022E-011$   
Shear Force,  $V_a = -7.6985341E-015$   
EDGE -B-  
Bending Moment,  $M_b = 7.0728943E-011$   
Shear Force,  $V_b = 7.6985341E-015$   
BOTH EDGES  
Axial Force,  $F = -29773.887$   
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,  $Db_{L,ten} = 17.20$

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Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = *V_n = 265894.097$   
From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_n < 0.83*fc'^{0.5}*h*d = 312816.585$

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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).

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From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 124920.997$   
 $M_u/V_u - l_w/2 = 12434.667 > 0$   
= 1 (normal-weight concrete)  
 $fc' = 16.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 3000.00$   
 $d = 200.00$   
 $l_w = 250.00$   
 $M_u = 9.6691022E-011$   
 $V_u = 7.6985341E-015$   
 $N_u = 29773.887$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$   
 $V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:  
 $d = 200.00$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$$2(1-s/d) = 0.50$$

Vs2 = 41887.902 is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$$2(1-s/d) = 0.50$$

Vs3 = 0.00 is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 400.00$$

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.

orientation 1:  $\theta = b_1 + 90^\circ = 90.00$

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

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

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

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

$$E_f = 64828.00$$

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

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

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

$$b_w = 3000.00$$

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

At local axis: 2

Integration Section: (a)  
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## Calculation No. 2

wall W1, Floor 1

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

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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

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 Knowledge Factor,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####  
 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 = 1.00406  
 Element Length,  $L = 3000.00$

Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Lap Length  $l_o = 300.00$   
 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,  $R = 40.00$

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 Stepwise Properties

-----  
 At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = 6.3108872E-029$   
 EDGE -B-  
 Shear Force,  $V_b = -6.3108872E-029$

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,  $V_e/V_r = 1.01783$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.0413E+009$

$Mu_{1+} = 2.8453E+009$ , 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

$Mu_{1-} = 3.0413E+009$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.0413E+009$

$Mu_{2+} = 2.8453E+009$ , 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

$Mu_{2-} = 3.0413E+009$ , 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  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.2735554E-006$

$Mu = 2.8453E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00232618$

$N = 27514.027$

$f_c = 16.00$

$\alpha_1$  (5A.5, TBDY) = 0.002

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

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

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

$\phi_{we}$  ((5.4c), TBDY) =  $\alpha_1 * \phi_{we} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi = \alpha_1 * \phi_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.00$

$\phi_{fe} = 0.00$

$b = 250.00$

$h = 3000.00$

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

$b_w = 250.00$

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

$\phi_y = 0.00$

$\phi_{fe} = 0.00$

$b = 3000.00$

$h = 250.00$

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

$b_w = 3000.00$

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

R = 40.00  
 Effective FRP thickness,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$   
 $ase_1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $ase_2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$   
 $ase_3 = 0$  (grid does not provide confinement)  
 $psh_{,min} = \min(psh_{,x}, psh_{,y}) = 0.00069813$

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

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x}$  (column 1) =  $(As_1 \cdot h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x}$  (column 2) =  $(As_2 \cdot h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x}$  (web) =  $(As_3 \cdot h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $As_3 = Astir_3 \cdot ns_3 = 0.00$   
 No stirrups,  $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y}$  (column 1) =  $(As_1 \cdot h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y}$  (column 2) =  $(As_2 \cdot h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y}$  (web) =  $(As_3 \cdot h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$   
 No stirrups,  $ns_3 = 0.00$

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c =$  confinement factor = 1.00406

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $l_0 / l_{ou,min} = l_b / l_d = 0.31638566$

$$su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_1\_nominal = 0.08066667$ ,

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

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

with  $fs_1 = fs = 290.1959$

with  $Es_1 = Es = 200000.00$

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$su_2 = 0.00579712$$

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

$$lo/lo_{ou,min} = lb/lb_{min} = 0.31638566$$

$$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_2\_nominal = 0.08066667$ ,

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

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

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

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

$$lo/lo_{ou,min} = lb/ld = 0.31638566$$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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

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

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

with  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.07029503$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.07029503$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.09344146$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.09344146$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

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$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

Id = 948.2098

Calculation of  $I_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

db = 16.85714

Mean strength value of all re-bars:  $f_y = 500.00$

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.24399

n = 28.00

Calculation of  $\mu_1$ -

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

$\mu = 2.2880917E-006$

$\mu = 3.0413E+009$

with full section properties:

b = 250.00

d = 2957.00

d' = 43.00

v = 0.00232618

N = 27514.027

$f_c = 16.00$

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

Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu, \alpha) = 0.0035$

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

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

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

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

$f_x = 0.00$

$\alpha_f = 0.00$

b = 250.00

h = 3000.00

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

bw = 250.00

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

$f_y = 0.00$

$\alpha_f = 0.00$

b = 3000.00

h = 250.00

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

bw = 3000.00

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

R = 40.00

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}$  ((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 = 150.00

bo\_1 = 190.00

ho\_1 = 540.00

bi2\_1 = 655400.00

$\alpha_{se2} = 0.00$

sh\_2 = 150.00

bo\_2 = 190.00

ho\_2 = 540.00

$$bi2\_2 = 655400.00$$

ase3 = 0 (grid does not provide confinement)

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$$

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

$$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$$

$$ps1,x \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00083776$$

$$h1 = 600.00$$

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

No stirrups, ns1 = 2.00

$$ps2,x \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00083776$$

$$h2 = 600.00$$

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

No stirrups, ns2 = 2.00

$$ps3,x \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00188496$$

$$h3 = 1800.00$$

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

No stirrups, ns3 = 2.00

$$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$$

$$ps1,y \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00034907$$

$$h1 = 250.00$$

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

No stirrups, ns1 = 2.00

$$ps2,y \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

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

No stirrups, ns2 = 2.00

$$ps3,y \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00$$

$$h3 = 250.00$$

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

No stirrups, ns3 = 0.00

$$Asec = 750000.00$$

$$s\_1 = 150.00$$

$$s\_2 = 150.00$$

$$s\_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

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

$$lo/lou,min = lb/l_d = 0.31638566$$

$$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

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

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

with fs1 = fs = 290.1959

with Es1 = Es = 200000.00

$$y2 = 0.00120915$$

$$sh2 = 0.00467215$$

$$ft2 = 348.235$$

$$fy2 = 290.1959$$

$$su2 = 0.00579712$$

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

$$lo/lou,min = lb/l_{b,min} = 0.31638566$$

$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_2\_nominal = 0.08066667$ ,  
 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  $fs_2 = fs = 290.1959$   
 with  $Es_2 = Es = 200000.00$   
 $yv = 0.00120915$   
 $shv = 0.00467215$   
 $ftv = 348.235$   
 $fyv = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 290.1959$   
 with  $Es_v = Es = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07029503$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07029503$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01510726$

and confined core properties:

$b = 190.00$   
 $d = 2927.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.09344146$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.09344146$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02008172$

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

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14318411$   
 $Mu = MRc (4.14) = 3.0413E+009$   
 $u = su (4.1) = 2.2880917E-006$

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

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.24399$   
 $n = 28.00$

-----  
 Calculation of  $Mu_{2+}$   
 -----

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

$$u = 2.2735554E-006$$

$$\mu = 2.8453E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$\phi_x = 0.00$$

$$\alpha f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\phi_y = 0.00$$

$$\alpha f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha s_e \text{ ((5.4d), TBDY) } = (\alpha s_{e1} * A_{col1} + \alpha s_{e2} * A_{col2} + \alpha s_{e3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha s_{e1} = 0.00$$

$$s_{h,1} = 150.00$$

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

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

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

$$\alpha s_{e2} = 0.00$$

$$s_{h,2} = 150.00$$

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

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

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

$$\alpha s_{e3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh, \text{min}} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

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

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1) } = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

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

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

$$p_{s2,x} \text{ (column 2) } = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

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

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

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

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

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/l\_d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

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

with fs1 = fs = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

lo/lou,min = lb/l\_b,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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

with fs2 = fs = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

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

lo/lou,min = lb/l\_d = 0.31638566

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07029503$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07029503$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$c =$  confinement factor = 1.00406

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09344146$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09344146$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

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

Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $Mu2$ -

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

$$u = 2.2880917E-006$$

$$Mu = 3.0413E+009$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$fc = 16.00$$

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

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

The  $\text{Shear\_factor}$  is considered equal to 1 (pure moment strength)

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

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

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

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 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) =  $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$a_{se2} = 0.00$

$sh_{,2} = 150.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

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

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

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

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00083776$

$h_1 = 600.00$

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

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00083776$

$h_2 = 600.00$

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

No stirrups,  $n_{s2} = 2.00$

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

$h_3 = 1800.00$

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

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

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

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

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

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (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, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07029503

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07029503

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01510726

and confined core properties:

b = 190.00

d = 2927.00

d' = 13.00

fcc (5A.2, TBDY) = 16.06499

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09344146$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09344146$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.02008172$$

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

--->

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

--->

$$su (4.9) = 0.14318411$$

$$Mu = MRc (4.14) = 3.0413E+009$$

$$u = su (4.1) = 2.2880917E-006$$

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

-----  
Lap Length:  $l_b/l_d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.9920E+006$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r1} = V_n < 0.83*fc'^{0.5}*h*d$

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

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

$$Mu/V_u - l_w/2 = 0.00 <= 0$$

= 1 (normal-weight concrete)

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

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$Mu = 2.8012401E-010$$

$$V_u = 6.3108872E-029$$

$$Nu = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

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

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

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|), \text{ with:}$$

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

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

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

$$E_f = 64828.00$$

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

with  $f_u = 0.01$

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

$$b_w = 250.00$$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920E+006$

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) 'Vw' is replaced by 'Vw + f \* V\_f'  
where V\_f is the contribution of FRPs (11.3), ACI 440).

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

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

= 1 (normal-weight concrete)

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

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$\mu_u = 2.8012401E-010$$

$$\nu_u = 6.3108872E-029$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

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

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

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|), \text{ with:}$$

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  
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 = 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,  $\gamma = 0.85$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$

#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####  
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 = 1.00406  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
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,  $V_a = 0.00$   
EDGE -B-  
Shear Force,  $V_b = 0.00$   
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:  $As_{,ten} = 2368.761$

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

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

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

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.14054053$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7738E+008$

$Mu_{1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7738E+008$

$Mu_{2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

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

$\phi_u = 3.4223799E-005$

$M_u = 1.4516E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.0035$

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

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

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

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

$\phi_x = 0.00$

$\phi_y = 0.00$

$b = 250.00$

$h = 3000.00$

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

$b_w = 250.00$

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

$\phi_y = 0.00$

$\phi_x = 0.00$

$b = 3000.00$

$h = 250.00$

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

$b_w = 3000.00$

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

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 * A_{col1} + ase_2 * A_{col2} + ase_3 * A_{web}) / A_{sec} = 0.00$   
 $ase_1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $ase_2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$   
 $ase_3 = 0$  (grid does not provide confinement)  
 $psh_{,min} = \text{Min}(psh_{,x}, psh_{,y}) = 0.00069813$

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

-----

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $As_3 = Astir_3 * ns_3 = 0.00$   
 No stirrups,  $ns_3 = 2.00$

-----

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $As_3 = Astir_3 * ns_3 = 157.0796$   
 No stirrups,  $ns_3 = 0.00$

-----

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

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

$l_o / l_{ou,min} = l_b / l_d = 0.31638566$   
 $su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.03226667$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08066667$ ,

For 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  $fs1 = fs = 290.1959$

with  $Es1 = Es = 200000.00$

$y2 = 0.00120915$

$sh2 = 0.00467215$

$ft2 = 348.235$

$fy2 = 290.1959$

$su2 = 0.00579712$

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

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

$Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 0.31638566$

$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08066667$ ,

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  $fs2 = fs = 290.1959$

with  $Es2 = Es = 200000.00$

$yv = 0.00120915$

$shv = 0.00467215$

$ftv = 348.235$

$fyv = 290.1959$

$suv = 0.00579712$

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

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

$Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.31638566$

$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.06885062$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.06885062$

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

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$fcc (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c =$  confinement factor  $= 1.00406$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.08209659$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.08209659$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$su (4.9) = 0.18563201$

$Mu = MRc (4.14) = 1.4516E+008$

$u = su (4.1) = 3.4223799E-005$

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

-----  
Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $I_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$d_b = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_1$ -

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

$\mu = 3.5153739E-005$

$\mu = 1.7738E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

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

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

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

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

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

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

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$b_w = 250.00$

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

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$b_w = 3000.00$

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

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$\alpha_{se1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_{,2} = 150.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

ase3 = 0 (grid does not provide confinement)  
psh,min = Min(psh,x , psh,y) = 0.00069813  
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
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 = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00  
From ((5.A5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406  
y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_d = 0.31638566  
su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667  
From table 5A.1, TBDY: esu1\_nominal = 0.08066667,  
For 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 = 290.1959  
with Es1 = Es = 200000.00  
y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_b,min = 0.31638566  
su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $es_{u2\_nominal} = 0.08066667$ ,

For calculation of  $es_{u2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

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

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$

$sh_v = 0.00467215$

$ft_v = 348.235$

$fy_v = 290.1959$

$s_{uv} = 0.00579712$

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

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

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.31638566$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $es_{uv\_nominal} = 0.08066667$ ,

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

with  $fs_v = fs = 290.1959$

with  $Es_v = Es = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/fc) = 0.06885062$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/fc) = 0.06885062$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/fc) = 0.04675268$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$f_{cc} (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c = \text{confinement factor} = 1.00406$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/fc) = 0.08209659$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/fc) = 0.08209659$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/fc) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$s_u (4.9) = 0.20717489$

$\mu_u = MR_c (4.14) = 1.7738E+008$

$u = s_u (4.1) = 3.5153739E-005$

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

Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$db = 16.85714$

Mean strength value of all re-bars:  $fy = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

-----  
Calculation of  $\mu_{u2+}$

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

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

$$\omega_e \text{ ((5.4c), TBDY) } = \alpha s_e * \text{sh}_{, \text{min}} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$$

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

$$\phi_x = 0.00$$

$$\alpha f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\phi_y = 0.00$$

$$\alpha f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha s_e \text{ ((5.4d), TBDY) } = (\alpha s_{e1} * A_{col1} + \alpha s_{e2} * A_{col2} + \alpha s_{e3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha s_{e1} = 0.00$$

$$\text{sh}_{,1} = 150.00$$

$$\text{bo}_{,1} = 190.00$$

$$\text{ho}_{,1} = 540.00$$

$$\text{bi}_{2,1} = 655400.00$$

$$\alpha s_{e2} = 0.00$$

$$\text{sh}_{,2} = 150.00$$

$$\text{bo}_{,2} = 190.00$$

$$\text{ho}_{,2} = 540.00$$

$$\text{bi}_{2,2} = 655400.00$$

$$\alpha s_{e3} = 0 \text{ (grid does not provide confinement)}$$

$$\text{psh}_{, \text{min}} = \text{Min}(\text{psh}_{,x}, \text{psh}_{,y}) = 0.00069813$$

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

$$\text{psh}_{,x} = \text{ps}_{1,x} + \text{ps}_{2,x} + \text{ps}_{3,x} = 0.00356047$$

$$\text{ps}_{1,x} \text{ (column 1) } = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

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

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

$$\text{ps}_{2,x} \text{ (column 2) } = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

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

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

$$\text{ps}_{3,x} \text{ (web) } = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

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

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
considering characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv, shv,ftv,fyv$ , it is considered  
characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = fs = 290.1959$   
with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.06885062$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.06885062$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.00$

and confined core properties:

$b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $fcc$  (5A.2, TBDY) = 16.06499  
 $cc$  (5A.5, TBDY) = 0.00204062  
 $c =$  confinement factor = 1.00406  
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.08209659$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08209659$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.00$

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

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

--->  
 $su$  (4.9) = 0.18563201  
 $Mu = MRc$  (4.14) = 1.4516E+008  
 $u = su$  (4.1) = 3.4223799E-005

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

-----  
Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$   
 $ld = 948.2098$

Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$db = 16.85714$   
Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.24399$   
 $n = 28.00$

-----  
Calculation of  $Mu2$ -

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

$u = 3.5153739E-005$   
 $Mu = 1.7738E+008$

-----  
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:  $cu = 0.0035$

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

$f_x = 0.00$   
 $a_f = 0.00$   
 $b = 250.00$   
 $h = 3000.00$   
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.008128$   
 $bw = 250.00$   
effective stress from (A.35),  $f_{f,e} = 636.1644$

$f_y = 0.00$   
 $a_f = 0.00$   
 $b = 3000.00$   
 $h = 250.00$   
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00067733$   
 $bw = 3000.00$   
effective stress from (A.35),  $f_{f,e} = 944.3987$

$R = 40.00$   
Effective FRP thickness,  $t_f = NL \cdot t \cdot \text{Cos}(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web})/A_{sec} = 0.00$   
 $a_{se1} = 0.00$   
 $s_{h,1} = 150.00$   
 $b_{o,1} = 190.00$   
 $h_{o,1} = 540.00$   
 $b_{i2,1} = 655400.00$   
 $a_{se2} = 0.00$   
 $s_{h,2} = 150.00$   
 $b_{o,2} = 190.00$   
 $h_{o,2} = 540.00$   
 $b_{i2,2} = 655400.00$   
 $a_{se3} = 0$  (grid does not provide confinement)  
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

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

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$   
 $p_{s1,x} (\text{column 1}) = (A_{s1} \cdot h_1/s_{,1})/A_c = 0.00083776$   
 $h_1 = 600.00$   
 $A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$   
No stirrups,  $n_{s1} = 2.00$   
 $p_{s2,x} (\text{column 2}) = (A_{s2} \cdot h_2/s_{,2})/A_c = 0.00083776$   
 $h_2 = 600.00$   
 $A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$   
No stirrups,  $n_{s2} = 2.00$   
 $p_{s3,x} (\text{web}) = (A_{s3} \cdot h_3/s_{,3})/A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$   
No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$   
 $p_{s1,y} (\text{column 1}) = (A_{s1} \cdot h_1/s_{,1})/A_c = 0.00034907$   
 $h_1 = 250.00$   
 $A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$   
No stirrups,  $n_{s1} = 2.00$   
 $p_{s2,y} (\text{column 2}) = (A_{s2} \cdot h_2/s_{,2})/A_c = 0.00034907$   
 $h_2 = 250.00$   
 $A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$   
No stirrups,  $n_{s2} = 2.00$   
 $p_{s3,y} (\text{web}) = (A_{s3} \cdot h_3/s_{,3})/A_c = 0.00$   
 $h_3 = 250.00$   
 $A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$   
No stirrups,  $n_{s3} = 0.00$

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

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

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

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

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 =  $Asl,ten/(b*d)*(fs1/fc) = 0.08209659$

2 =  $Asl,com/(b*d)*(fs2/fc) = 0.08209659$

v =  $Asl,mid/(b*d)*(fsv/fc) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

su (4.9) = 0.20717489

Mu = MRc (4.14) = 1.7738E+008

u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

Lap Length: lb/l<sub>d</sub> = 0.31638566

lb = 300.00

l<sub>d</sub> = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 2.24399

n = 28.00

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 841398.394

-----  
Calculation of Shear Strength at edge 1, Vr1 = 841398.394

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 = 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 = 1.9099438E-011

Vu = 0.00

Nu = 27514.027

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 + Vs3 = 83775.804

Vs1 = 41887.902 is calculated for pseudo-Column 1, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

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

2(1-s/d) = 0.50

Vs2 = 41887.902 is calculated for pseudo-Column 2, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

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

2(1-s/d) = 0.50

Vs3 = 0.00 is calculated for web, with:

$d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$   
 Vs3 has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.00$   
 $V_f$  ((11-3)-(11.4), 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  $\theta$  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  $\alpha_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \alpha)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L * t / \text{NoDir} = 1.016$   
 $d_{fv} = d$  (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,  $V_{r2} = 841398.394$   
 From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r2} = V_n < 0.83 * f_c'^{0.5} * h * d$

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

-----  
 From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$   
 $\mu_u / V_u - l_w / 2 = 0.00 \leq 0$   
 $= 1$  (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 3000.00$   
 $d = 200.00$   
 $l_w = 250.00$   
 $\mu_u = 1.9099438E-011$   
 $V_u = 0.00$   
 $N_u = 27514.027$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$   
 $V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s3} = 0.00$  is calculated for web, with:  
 $d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$   
 $V_{s3}$  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  $\theta$  is the angle of the crack direction (see KANEPE).

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

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

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

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

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

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

$E_f = 64828.00$

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

with  $f_u = 0.01$

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

$b_w = 3000.00$

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

At local axis: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rcrws

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.85$

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

$\rho_n = 0.00069813$

-----  
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  $\rho_{s1} = A_{s1} * b_1 / s_1 = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$s_1 = 150.00$

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

(pseudo-col.2  $\rho_{s2} = A_{s2} * b_2 / s_2 = (A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$s_2 = 150.00$

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

(grid  $\rho_{s3} = A_{s3} * b_3 / s_3 = (A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$s_3 = 200.00$

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

total section area,  $A_c = 750000.00$

-----  
Consequently:

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at  $135^\circ$ )

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

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,  $F = -29773.887$   
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,  $DbL = 17.33333$

-----  
-----  
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  $u_{,R} = * u = 0.004$   
from table 10-20:  $u = 0.00470588$   
with:

- Condition i (shear wall and wall segments)  
-  $(As - As') * f_y + P) / (t_w * l_w * f_c') = -0.20905275$   
 $As = 0.00$   
 $As' = 6346.017$   
 $f_y = 400.00$   
 $P = 29773.887$   
 $t_w = 250.00$   
 $l_w = 3000.00$   
 $f_c = 16.00$

-----  
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: Immediate Occupancy (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,  $\gamma = 0.85$

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

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,  $M_a = 1.0286E+008$

Shear Force,  $V_a = -34419.312$

EDGE -B-

Bending Moment,  $M_b = 420173.225$

Shear Force,  $V_b = 34419.312$

BOTH EDGES

Axial Force,  $F = -29773.887$

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:  $As_{c,mid} = 615.7522$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.33333$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = V_n = 1.6932E+006$

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:  $V_c = 613369.253$

$\mu_u / \mu - l_w / 2 = 1488.32 > 0$

= 1 (normal-weight concrete)

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

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 1.0286E+008$

$V_u = 34419.312$

$N_u = 29773.887$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$V_{s3} = 452389.342$  is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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  $\alpha$  is the angle of the crack direction (see KANEPE).

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

orientation 1:  $\alpha = 45^\circ$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, 1)|)$ , 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:  $Vs + Vf \leq 1.5943E+006$   
 $bw = 250.00$

-----  
 End Of Calculation of Shear Capacity for element: wall W1 of floor 1  
 At local axis: 3  
 Integration Section: (a)  
 -----

**Calculation No. 4**

wall W1, Floor 1  
 Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)  
 Analysis: Uniform +X  
 Check: Chord rotation capacity (  $\theta$  )  
 Edge: Start  
 Local Axis: (3)



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

Constant Properties

-----  
 Knowledge Factor,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####

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 = 1.00406

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = 300.00$

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,  $V_a = 6.3108872E-029$

EDGE -B-

Shear Force,  $V_b = -6.3108872E-029$

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 ,  $V_e/V_r = 1.01783$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$

with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 3.0413E+009$

$M_{u1+} = 2.8453E+009$ , 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

$M_{u1-} = 3.0413E+009$ , 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

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 3.0413E+009$

$M_{u2+} = 2.8453E+009$ , 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

$M_{u2-} = 3.0413E+009$ , 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  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2735554E-006$$

$$\mu = 2.8453E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$\phi_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\phi_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$s_{h,1} = 150.00$$

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

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

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

$$a_{se2} = 0.00$$

$$s_{h,2} = 150.00$$

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

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

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

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

$$p_{sh, \min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

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

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00083776$$

$$h_1 = 600.00$$

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

No stirrups,  $n_{s1} = 2.00$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00083776$$

$$h_2 = 600.00$$

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

No stirrups,  $n_{s2} = 2.00$

$$ps_{3,x}(\text{web}) = (As_3 \cdot h_3 / s_3) / Ac = 0.00188496$$

$$h_3 = 1800.00$$

$$As_3 = Astir_3 \cdot ns_3 = 0.00$$

$$\text{No stirups, } ns_3 = 2.00$$

$$psh_y = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$$

$$ps_{1,y}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / Ac = 0.00034907$$

$$h_1 = 250.00$$

$$As_1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$ps_{2,y}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / Ac = 0.00034907$$

$$h_2 = 250.00$$

$$As_2 = Astir_2 \cdot ns_2 = 157.0796$$

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

$$ps_{3,y}(\text{web}) = (As_3 \cdot h_3 / s_3) / Ac = 0.00$$

$$h_3 = 250.00$$

$$As_3 = Astir_3 \cdot ns_3 = 157.0796$$

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

$$A_{sec} = 750000.00$$

$$s_1 = 150.00$$

$$s_2 = 150.00$$

$$s_3 = 200.00$$

$$f_{ywe} = 500.00$$

$$f_{ce} = 16.00$$

$$\text{From } ((5A5), \text{TB DY}), \text{TB DY: } cc = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$y_1 = 0.00120915$$

$$sh_1 = 0.00467215$$

$$ft_1 = 348.235$$

$$fy_1 = 290.1959$$

$$su_1 = 0.00579712$$

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

$$lo/lou, \text{min} = lb/l_d = 0.31638566$$

$$su_1 = 0.4 \cdot esu_{1,nominal} ((5.5), \text{TB DY}) = 0.03226667$$

$$\text{From table 5A.1, TB DY: } esu_{1,nominal} = 0.08066667,$$

For calculation of esu<sub>1,nominal</sub> and y<sub>1</sub>, sh<sub>1</sub>, ft<sub>1</sub>, fy<sub>1</sub>, it is considered  
characteristic value fsy<sub>1</sub> = fs<sub>1</sub>/1.2, from table 5.1, TB DY.

y<sub>1</sub>, sh<sub>1</sub>, ft<sub>1</sub>, fy<sub>1</sub>, are also multiplied by Min(1, 1.25 \* (lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 290.1959$$

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

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$su_2 = 0.00579712$$

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

$$lo/lou, \text{min} = lb/l_{b,\text{min}} = 0.31638566$$

$$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), \text{TB DY}) = 0.03226667$$

$$\text{From table 5A.1, TB DY: } esu_{2,nominal} = 0.08066667,$$

For calculation of esu<sub>2,nominal</sub> and y<sub>2</sub>, sh<sub>2</sub>, ft<sub>2</sub>, fy<sub>2</sub>, it is considered  
characteristic value fsy<sub>2</sub> = fs<sub>2</sub>/1.2, from table 5.1, TB DY.

y<sub>1</sub>, sh<sub>1</sub>, ft<sub>1</sub>, fy<sub>1</sub>, are also multiplied by Min(1, 1.25 \* (lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 290.1959$$

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

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$su_v = 0.00579712$$

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

$$l_0/l_{ou,min} = l_b/d = 0.31638566$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.03226667$$

$$\text{From table 5A.1, TBDY: } e_{suv,nominal} = 0.08066667,$$

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

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

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

$$\text{with } f_{sv} = f_s = 290.1959$$

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.07029503$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.07029503$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.09344146$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.09344146$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.13770595$$

$$M_u = M_{Rc} (4.14) = 2.8453E+009$$

$$u = s_u (4.1) = 2.2735554E-006$$

Calculation of ratio  $l_b/d$

$$\text{Lap Length: } l_b/d = 0.31638566$$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

Calculation of  $Mu_1$ -

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

$$u = 2.2880917E-006$$

$$M_u = 3.0413E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, cc) = 0.0035$$

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

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

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

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) =  $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$a_{se2} = 0.00$

$sh_{,2} = 150.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

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

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

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

-----  
 $p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00083776$

$h_1 = 600.00$

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

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00083776$

$h_2 = 600.00$

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

No stirrups,  $n_{s2} = 2.00$

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

$h_3 = 1800.00$

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

No stirrups,  $n_{s3} = 2.00$

-----  
 $p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

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

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

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

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

As3 = Astir3\*ns3 = 157.0796  
No stirups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07029503

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07029503

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01510726

and confined core properties:

b = 190.00

d = 2927.00

d' = 13.00

$$f_{cc} (5A.2, \text{TBDY}) = 16.06499$$

$$c_c (5A.5, \text{TBDY}) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09344146$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09344146$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02008172$$

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

--->

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

--->

$$s_u (4.9) = 0.14318411$$

$$M_u = M_{Rc} (4.14) = 3.0413E+009$$

$$u = s_u (4.1) = 2.2880917E-006$$

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

$$\text{Lap Length: } l_b/l_d = 0.31638566$$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \text{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $M_{u2+}$

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

$$u = 2.2735554E-006$$

$$M_u = 2.8453E+009$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

h = 250.00  
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,  $tf = NL*t*\text{Cos}(b1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase((5.4d), \text{TBDY}) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$   
ase1 = 0.00  
sh\_1 = 150.00  
bo\_1 = 190.00  
ho\_1 = 540.00  
bi2\_1 = 655400.00  
ase2 = 0.00  
sh\_2 = 150.00  
bo\_2 = 190.00  
ho\_2 = 540.00  
bi2\_2 = 655400.00  
ase3 = 0 (grid does not provide confinement)  
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$

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

$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$   
 $ps1,x$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00083776$   
h1 = 600.00  
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups, ns1 = 2.00  
 $ps2,x$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00083776$   
h2 = 600.00  
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups, ns2 = 2.00  
 $ps3,x$  (web) =  $(As3*h3/s_3)/Ac = 0.00188496$   
h3 = 1800.00  
 $As3 = Astir3*ns3 = 0.00$   
No stirrups, ns3 = 2.00

$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$   
 $ps1,y$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00034907$   
h1 = 250.00  
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups, ns1 = 2.00  
 $ps2,y$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00034907$   
h2 = 250.00  
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups, ns2 = 2.00  
 $ps3,y$  (web) =  $(As3*h3/s_3)/Ac = 0.00$   
h3 = 250.00  
 $As3 = Astir3*ns3 = 157.0796$   
No stirrups, ns3 = 0.00

Asec = 750000.00  
s\_1 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00

$f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

$$l_o/l_{ou,min} = l_b/l_d = 0.31638566$$

$$s_u1 = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08066667$ ,

For calculation of  $e_{su1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.

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

$$\text{with } f_{s1} = f_s = 290.1959$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$s_u2 = 0.00579712$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.31638566$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $e_{su2,nominal} = 0.08066667$ ,

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

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

$$\text{with } f_{s2} = f_s = 290.1959$$

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

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$s_{uv} = 0.00579712$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.31638566$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08066667$ ,

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

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

$$\text{with } f_{sv} = f_s = 290.1959$$

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

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.07029503$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.07029503$$

$$v = A_{s1,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.09344146$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.09344146$$

$$v = A_{s1,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.13770595$$

$$\mu_u = M_{Rc} (4.14) = 2.8453E+009$$

$$u = s_u (4.1) = 2.2735554E-006$$

Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.31638566$

$l_b = 300.00$

$l_d = 948.2098$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$= 1$

$d_b = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_2$

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

$\mu = 2.2880917E-006$

$\mu = 3.0413E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00232618$

$N = 27514.027$

$f_c = 16.00$

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

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

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

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

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

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

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$\alpha_{se1} = 0.00$

$sh_1 = 150.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi_{2,1} = 655400.00$

ase2 = 0.00  
sh\_2 = 150.00  
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) = 0.00069813

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

-----  
psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
h2 = 600.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,x (web) = (As3\*h3/s\_3)/Ac = 0.00188496  
h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirrups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
h2 = 250.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,y (web) = (As3\*h3/s\_3)/Ac = 0.00  
h3 = 250.00  
As3 = Astir3\*ns3 = 157.0796  
No stirrups, ns3 = 0.00

-----  
Asec = 750000.00  
s\_1 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.31638566$

$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08066667$ ,

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

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

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$

$sh_v = 0.00467215$

$ft_v = 348.235$

$fy_v = 290.1959$

$su_v = 0.00579712$

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

$l_o/l_{o,min} = l_b/l_d = 0.31638566$

$su_v = 0.4 * esu_{v,nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esu_{v,nominal} = 0.08066667$ ,

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

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

with  $fsv = fs = 290.1959$

with  $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.07029503$

$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.07029503$

$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.01510726$

and confined core properties:

$b = 190.00$

$d = 2927.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c =$  confinement factor  $= 1.00406$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09344146$

$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09344146$

$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.02008172$

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

--->

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

--->

$su (4.9) = 0.14318411$

$Mu = MRc (4.14) = 3.0413E+009$

$u = su (4.1) = 2.2880917E-006$

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

Lap Length:  $l_b/l_d = 0.31638566$

$l_b = 300.00$

$l_d = 948.2098$

Calculation of  $l_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$= 1$

$db = 16.85714$

Mean strength value of all re-bars:  $fy = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$   
-----

-----  
-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.9920\text{E}+006$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920\text{E}+006$   
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:  $V_c = 653502.805$

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

= 1 (normal-weight concrete)

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

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 2.8012401\text{E}-010$

$V_u = 6.3108872\text{E}-029$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$V_{s3} = 452389.342$  is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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)  $\sin \theta + \cos \theta$  is replaced with  $(\cot \theta + \csc \theta) \sin \alpha$  which is more a generalised expression,

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

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

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

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

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

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

$b_w = 250.00$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920\text{E}+006$

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:  $V_c = 653502.805$

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

= 1 (normal-weight concrete)

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

h = 250.00

d = 2400.00

lw = 3000.00

Mu = 2.8012401E-010

Vu = 6.3108872E-029

Nu = 27514.027

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

d = 480.00

$A_v = 157079.633$

s = 150.00

$f_y = 400.00$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

d = 480.00

$A_v = 157079.633$

s = 150.00

$f_y = 400.00$

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

$V_{s3} = 452389.342$  is calculated for web, with:

d = 1440.00

$A_v = 157079.633$

s = 200.00

$f_y = 400.00$

$V_{s3}$  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,  $t_{f1} = NL * t / \text{NoDir} = 1.016$

$d_{fv} = d$  (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 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,  $\gamma = 0.85$

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

Consequently:

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

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$   
#####  
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 = 1.00406  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
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,  $V_a = 0.00$   
EDGE -B-  
Shear Force,  $V_b = 0.00$   
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 ,  $V_e/V_r = 0.14054053$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.7738E+008$   
 $\mu_{u1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $\mu_{u1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 1.7738E+008$   
 $\mu_{u2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $\mu_{u2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

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

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

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$\phi_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\phi_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$sh_1 = 150.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 150.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

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

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00069813$$

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

$$\phi_{sh,x} = \phi_{ps1,x} + \phi_{ps2,x} + \phi_{ps3,x} = 0.00356047$$

$$\phi_{ps1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

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

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

$$\phi_{ps2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

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

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

$$\phi_{ps3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

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

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/l\_d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

lo/lou,min = lb/l\_b,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

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

lo/lou,min = lb/l\_d = 0.31638566

$$\text{su} = 0.4 * \text{esuv\_nominal} ((5.5), \text{TBDY}) = 0.03226667$$

From table 5A.1, TBDY:  $\text{esuv\_nominal} = 0.08066667$ ,

considering characteristic value  $\text{fsy} = \text{fsv}/1.2$ , from table 5.1, TBDY

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

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

with  $\text{fsv} = \text{fs} = 290.1959$

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

$$1 = \text{Asl,ten}/(\text{b} * \text{d}) * (\text{fs1}/\text{fc}) = 0.06885062$$

$$2 = \text{Asl,com}/(\text{b} * \text{d}) * (\text{fs2}/\text{fc}) = 0.06885062$$

$$v = \text{Asl,mid}/(\text{b} * \text{d}) * (\text{fsv}/\text{fc}) = 0.00$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$\text{fcc} (5A.2, \text{TBDY}) = 16.06499$$

$$\text{cc} (5A.5, \text{TBDY}) = 0.00204062$$

$c$  = confinement factor = 1.00406

$$1 = \text{Asl,ten}/(\text{b} * \text{d}) * (\text{fs1}/\text{fc}) = 0.08209659$$

$$2 = \text{Asl,com}/(\text{b} * \text{d}) * (\text{fs2}/\text{fc}) = 0.08209659$$

$$v = \text{Asl,mid}/(\text{b} * \text{d}) * (\text{fsv}/\text{fc}) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < \text{vs,y2}$  - LHS eq.(4.5) is satisfied

---

$$\text{su} (4.9) = 0.18563201$$

$$\text{Mu} = \text{MRc} (4.14) = 1.4516\text{E}+008$$

$$u = \text{su} (4.1) = 3.4223799\text{E}-005$$

Calculation of ratio  $\text{lb}/\text{ld}$

Lap Length:  $\text{lb}/\text{ld} = 0.31638566$

$$\text{lb} = 300.00$$

$$\text{ld} = 948.2098$$

Calculation of  $\text{lb,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$\text{db} = 16.85714$$

Mean strength value of all re-bars:  $\text{fy} = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$\text{cb} = 25.00$$

$$\text{Ktr} = 2.24399$$

$$n = 28.00$$

Calculation of  $\text{Mu1}$ -

Calculation of ultimate curvature  $\text{u}$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.5153739\text{E}-005$$

$$\text{Mu} = 1.7738\text{E}+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$\text{fc} = 16.00$$

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

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

The  $\text{Shear\_factor}$  is considered equal to 1 (pure moment strength)

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

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

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)

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$bw = 250.00$

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

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$bw = 3000.00$

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

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$a_{se1} = 0.00$

$s_{h,1} = 150.00$

$b_{o,1} = 190.00$

$h_{o,1} = 540.00$

$b_{i2,1} = 655400.00$

$a_{se2} = 0.00$

$s_{h,2} = 150.00$

$b_{o,2} = 190.00$

$h_{o,2} = 540.00$

$b_{i2,2} = 655400.00$

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

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

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

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

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

$h_3 = 1800.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$

No stirups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.08209659$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08209659$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05574729$$

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

--->

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

--->

$$su (4.9) = 0.20717489$$

$$Mu = MRc (4.14) = 1.7738E+008$$

$$u = su (4.1) = 3.5153739E-005$$

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

-----  
Lap Length:  $l_b/l_d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $Mu_{2+}$

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

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

-----  
with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$af = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$bw = 250.00$$

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

$$f_y = 0.00$$

$$af = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

From EC8 A4.4.3(6),  $pf = 2tf/bw = 0.00067733$   
 $bw = 3000.00$   
effective stress from (A.35),  $ff,e = 944.3987$

-----  
 $R = 40.00$   
Effective FRP thickness,  $tf = NL*t*\text{Cos}(b1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase((5.4d), \text{TBDY}) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$   
 $ase1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi2_1 = 655400.00$   
 $ase2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi2_2 = 655400.00$   
 $ase3 = 0$  (grid does not provide confinement)  
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$

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

-----  
 $psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$   
 $ps1,x$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00083776$   
 $h1 = 600.00$   
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups,  $ns1 = 2.00$   
 $ps2,x$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00083776$   
 $h2 = 600.00$   
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups,  $ns2 = 2.00$   
 $ps3,x$  (web) =  $(As3*h3/s_3)/Ac = 0.00188496$   
 $h3 = 1800.00$   
 $As3 = Astir3*ns3 = 0.00$   
No stirrups,  $ns3 = 2.00$

-----  
 $psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$   
 $ps1,y$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00034907$   
 $h1 = 250.00$   
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups,  $ns1 = 2.00$   
 $ps2,y$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00034907$   
 $h2 = 250.00$   
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups,  $ns2 = 2.00$   
 $ps3,y$  (web) =  $(As3*h3/s_3)/Ac = 0.00$   
 $h3 = 250.00$   
 $As3 = Astir3*ns3 = 157.0796$   
No stirrups,  $ns3 = 0.00$

-----  
 $Asec = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $fywe = 500.00$   
 $fce = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$

$y1 = 0.00120915$   
 $sh1 = 0.00467215$   
 $ft1 = 348.235$   
 $fy1 = 290.1959$   
 $su1 = 0.00579712$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

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

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

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

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

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

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) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.08209659

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08209659

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) = 0.18563201

Mu = MRc (4.14) = 1.4516E+008

u = su (4.1) = 3.4223799E-005

-----  
Calculation of ratio lb/d

Lap Length:  $l_b/l_d = 0.31638566$

$l_b = 300.00$

$l_d = 948.2098$

Calculation of  $l_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$= 1$

$db = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_2$ -

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

$\mu = 3.5153739E-005$

$\mu_u = 1.7738E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

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

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

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

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

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

where  $f = \alpha f * p_f * f_{fe} / f_{ce}$  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),  $f_{f,e} = 636.1644$

$f_y = 0.00$

$\alpha f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$b_w = 3000.00$

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

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha s e$  ((5.4d), TBDY) =  $(\alpha s e_1 * A_{col1} + \alpha s e_2 * A_{col2} + \alpha s e_3 * A_{web}) / A_{sec} = 0.00$

$\alpha s e_1 = 0.00$

$sh_1 = 150.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi_{2,1} = 655400.00$

$\alpha s e_2 = 0.00$

sh\_2 = 150.00  
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) = 0.00069813

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

psh,x = ps1,x+ps2,x+ps3,x = 0.00356047

ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776

h1 = 600.00

As1 = Astir1\*ns1 = 157.0796

No stirrups, ns1 = 2.00

ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776

h2 = 600.00

As2 = Astir2\*ns2 = 157.0796

No stirrups, ns2 = 2.00

ps3,x (web) = (As3\*h3/s\_3)/Ac = 0.00188496

h3 = 1800.00

As3 = Astir3\*ns3 = 0.00

No stirrups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.00069813

ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907

h1 = 250.00

As1 = Astir1\*ns1 = 157.0796

No stirrups, ns1 = 2.00

ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907

h2 = 250.00

As2 = Astir2\*ns2 = 157.0796

No stirrups, ns2 = 2.00

ps3,y (web) = (As3\*h3/s\_3)/Ac = 0.00

h3 = 250.00

As3 = Astir3\*ns3 = 157.0796

No stirrups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

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

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

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348,235

fyv = 290.1959

suv = 0.00579712

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

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

Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.08209659

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08209659

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05574729

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.20717489

Mu = MRc (4.14) = 1.7738E+008

u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/ld

-----  
Lap Length: lb/ld = 0.31638566

lb = 300.00

ld = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.24399

n = 28.00

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 841398.394$

Calculation of Shear Strength at edge 1,  $V_{r1} = 841398.394$   
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:  $V_c = 653502.805$

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

= 1 (normal-weight concrete)

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

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 1.9099438E-011$

$V_u = 0.00$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$2(1-s/d) = 0.50$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$2(1-s/d) = 0.50$

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

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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)  $\sin \alpha + \cos \alpha$  is replaced with  $(\cot \alpha + \cot \alpha) \sin \alpha$  which is more a generalised expression,  
where  $\alpha$  is the angle of the crack direction (see KANEPE).

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

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

$V_f = \text{Min}(|V_f(45, \alpha)|, |V_f(-45, \alpha)|)$ , 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,  $V_{r2} = 841398.394$

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:  $V_c = 653502.805$

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

= 1 (normal-weight concrete)

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

$$h = 3000.00$$

$$d = 200.00$$

$$l_w = 250.00$$

$$\mu_u = 1.9099438E-011$$

$$V_u = 0.00$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$$2(1-s/d) = 0.50$$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$$2(1-s/d) = 0.50$$

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

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 400.00$$

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

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

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

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

$w_f/s_f = 1$  (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.

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

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

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

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

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

$$E_f = 64828.00$$

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

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

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

$$b_w = 3000.00$$

-----  
End Of Calculation of Shear Capacity 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,  $\gamma = 0.85$

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

$$\rho_n = 0.00069813$$

with  $n = ps1 + ps2 + ps3$ , being the shear reinf. ratio in a plane perpendicular to the shear axis 2

(pseudo-col.1  $ps1 = As1*b1/s1 = (As1*h1/s1) / Ac = 0.00034907$

$h1 = 250.00$

$s1 = 150.00$

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

(pseudo-col.2  $ps2 = As2*b2/s2 = (As2*h2/s2) / Ac = 0.00034907$

$h2 = 250.00$

$s2 = 150.00$

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 Secondary Member: Concrete Strength,  $fc = fc\_lower\_bound = 16.00$

Existing material of Secondary Member: Steel Strength,  $fs = fs\_lower\_bound = 400.00$

Concrete Elasticity,  $Ec = 21019.039$

Steel Elasticity,  $Es = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $lb = 300.00$

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,  $M = -9.6691022E-011$

Shear Force,  $V2 = -7.6985341E-015$

Shear Force,  $V3 = -34419.312$

Axial Force,  $F = -29773.887$

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  $u,R = * u = 0.00277127$

$u = y + p = 0.00326031$

- Calculation of  $y$  -

$$y = (M_y \cdot I_p) / (E I)_{\text{Eff}} = 0.00126031 \text{ ((10-5), ASCE 41-17)}$$
$$M_y = 1.5091 \text{E}+008$$
$$(E I)_{\text{Eff}} = 0.35 \cdot E_c \cdot I \text{ (table 10-5)}$$
$$E_c \cdot I = 8.2106 \text{E}+013$$
$$I_p = 0.5 \cdot d = 0.5 \cdot (0.8 \cdot h) = 240.00$$

Calculation of Yielding Moment  $M_y$

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

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$
$$y_{\text{ten}} = 8.7656668 \text{E}-006$$
$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 269.394$$
$$d = 208.00$$
$$y = 0.26122943$$
$$A = 0.01034702$$
$$B = 0.00628884$$
$$\text{with } p_t = 0.00379609$$
$$p_c = 0.00379609$$
$$p_v = 0.00257772$$
$$N = 29773.887$$
$$b = 3000.00$$
$$" = 0.20192308$$
$$y_{\text{comp}} = 2.5442941 \text{E}-005$$
$$\text{with } f_c^* \text{ (12.3, (ACI 440))} = 16.002$$
$$f_c = 16.00$$
$$f_l = 0.17503396$$
$$b = 3000.00$$
$$h = 250.00$$
$$A_g = 750000.00$$
$$\text{From (12.9), ACI 440: } k_a = 0.00364754$$
$$g = p_t + p_c + p_v = 0.0101699$$
$$r_c = 40.00$$
$$A_e/A_c = 0.52524587$$
$$\text{Effective FRP thickness, } t_f = N L^* t \cdot \text{Cos}(b_1) = 1.016$$
$$\text{effective strain from (12.5) and (12.12), } e_{fe} = 0.004$$
$$f_u = 0.01$$
$$E_f = 64828.00$$
$$E_c = 21019.039$$
$$y = 0.25894248$$
$$A = 0.0099958$$
$$B = 0.00611172$$
$$\text{with } E_s = 200000.00$$

Calculation of ratio  $l_b/d$

Lap Length:  $l_d/d, \text{min} = 0.39548208$

$$l_b = 300.00$$

$$l_d = 758.5679$$

Calculation of  $l$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 400.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

- Calculation of  $p$  -

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

with:

- Condition i (shear wall and wall segments)

-  $(A_s - A_s') \cdot f_y + P / (t_w \cdot l_w \cdot f_c') = -0.20905275$

$A_s = 0.00$

$A_s' = 6346.017$

$f_y = 400.00$

$P = 29773.887$

$t_w = 3000.00$

$l_w = 250.00$

$f_c' = 16.00$

-  $V / (t_w \cdot l_w \cdot f_c' \cdot 0.5) = 3.0903667E-020$ , NOTE: units in lb & in

- Confined Boundary: No

Boundary hoops spacing exceed  $8d_b$  ( $s_1 > 8 \cdot d_b$  or  $s_2 > 8 \cdot d_b$ )

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:

$V_{w1} = 83775.804$

$s_1 = 150.00$

Boundary Element 2:

$V_{w2} = 83775.804$

$s_2 = 150.00$

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

Concrete Shear Force,  $V_c = 124920.997$

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

Mean diameter of all bars,  $d_b = 17.33333$

Design Shear Force,  $V = 7.6985341E-015$

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: Immediate Occupancy (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: (d)

Section Type: rcrws

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

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,  $M_a = -9.6691022E-011$

Shear Force,  $V_a = -7.6985341E-015$

EDGE -B-

Bending Moment,  $M_b = 7.0728943E-011$

Shear Force,  $V_b = 7.6985341E-015$

BOTH EDGES

Axial Force,  $F = -29773.887$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $Asl,c = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl,ten = 2368.761$

-Compression:  $Asl,com = 2368.761$

-Middle:  $Asl,mid = 1608.495$

Mean Diameter of Tension Reinforcement,  $DbL,ten = 17.20$

Existing component: From table 7-7, ASCE 41-17: Final Shear Capacity  $V_R = V_n = 267450.65$

From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_n < 0.83 \cdot f_c^{0.5} \cdot h \cdot d = 314647.823$

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:  $V_c = 126752.235$

$M_u/V_u - l_w/2 = 9062.326 > 0$

= 1 (normal-weight concrete)

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

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$M_u = 7.0728943E-011$

$V_u = 7.6985341E-015$

$N_u = 29773.887$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$2(1-s/d) = 0.50$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$2(1-s/d) = 0.50$

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

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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  $\theta$  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  $\alpha_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b_1 + 90^\circ = 90.00$

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

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

$d_{fv} = d$  (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: (d)

## Calculation No. 6

wall W1, Floor 1

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

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrcws

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

Consequently:

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

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####

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 = 1.00406

Element Length,  $L = 3000.00$

Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
FRP Wrapping Data  
Type: Carbon  
Cured laminate properties (design values)  
Thickness,  $t = 1.016$   
Tensile Strength,  $f_{fu} = 1055.00$   
Tensile Modulus,  $E_f = 64828.00$   
Elongation,  $e_{fu} = 0.01$   
Number of directions,  $NoDir = 1$   
Fiber orientations,  $b_i = 0.00^\circ$   
Number of layers,  $NL = 1$   
Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = 6.3108872E-029$   
EDGE -B-  
Shear Force,  $V_b = -6.3108872E-029$   
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 ,  $V_e/V_r = 1.01783$   
Member Controlled by Shear ( $V_e/V_r > 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.0413E+009$   
 $\mu_{1+} = 2.8453E+009$ , 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  
 $\mu_{1-} = 3.0413E+009$ , 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  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.0413E+009$   
 $\mu_{2+} = 2.8453E+009$ , 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  
 $\mu_{2-} = 3.0413E+009$ , 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  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 2.2735554E-006$   
 $M_u = 2.8453E+009$

with full section properties:

$b = 250.00$   
 $d = 2957.00$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

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

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$s_{h,1} = 150.00$$

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

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

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

$$a_{se2} = 0.00$$

$$s_{h,2} = 150.00$$

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

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

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

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

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

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

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

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

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

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

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

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

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

$$h_3 = 1800.00$$

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

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

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$$

$$h_1 = 250.00$$

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

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

$$ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

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

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

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

$$h3 = 250.00$$

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

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

$$Asec = 750000.00$$

$$s_1 = 150.00$$

$$s_2 = 150.00$$

$$s_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

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

$$lo/lou,min = lb/d = 0.31638566$$

$$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08066667,$$

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

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

$$\text{with } fs1 = fs = 290.1959$$

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

$$y2 = 0.00120915$$

$$sh2 = 0.00467215$$

$$ft2 = 348.235$$

$$fy2 = 290.1959$$

$$su2 = 0.00579712$$

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

$$lo/lou,min = lb/lb,min = 0.31638566$$

$$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esu2\_nominal = 0.08066667,$$

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

$$y2, sh2,ft2,fy2, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = fs = 290.1959$$

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

$$yv = 0.00120915$$

$$shv = 0.00467215$$

$$ftv = 348.235$$

$$fyv = 290.1959$$

$$suv = 0.00579712$$

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

$$lo/lou,min = lb/d = 0.31638566$$

$$suv = 0.4 \cdot esuv\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esuv\_nominal = 0.08066667,$$

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.

$$yv, shv,ftv,fyv, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = fs = 290.1959$$

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

$$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.07029503$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07029503$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 16.06499$$

$$c_c (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09344146$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09344146$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.13770595$$

$$M_u = M_{Rc} (4.14) = 2.8453E+009$$

$$u = s_u (4.1) = 2.2735554E-006$$

-----  
Calculation of ratio  $l_b/d$

-----  
Lap Length:  $l_b/d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $M_{u1}$ -

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

$$u = 2.2880917E-006$$

$$M_u = 3.0413E+009$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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:  $c_u = 0.0035$

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

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

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

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,  $tf = NL*t*\cos(b1) = 1.016$   
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 = 150.00  
bo\_1 = 190.00  
ho\_1 = 540.00  
bi2\_1 = 655400.00  
ase2 = 0.00  
sh\_2 = 150.00  
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) = 0.00069813  
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x = ps1,x + ps2,x + ps3,x = 0.00356047  
ps1,x (column 1) =  $(As1*h1/s_1)/Ac = 0.00083776$   
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,x (column 2) =  $(As2*h2/s_2)/Ac = 0.00083776$   
h2 = 600.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,x (web) =  $(As3*h3/s_3)/Ac = 0.00188496$   
h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirrups, ns3 = 2.00

psh,y = ps1,y + ps2,y + ps3,y = 0.00069813  
ps1,y (column 1) =  $(As1*h1/s_1)/Ac = 0.00034907$   
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,y (column 2) =  $(As2*h2/s_2)/Ac = 0.00034907$   
h2 = 250.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,y (web) =  $(As3*h3/s_3)/Ac = 0.00$   
h3 = 250.00  
As3 = Astir3\*ns3 = 157.0796  
No stirrups, ns3 = 0.00

Asec = 750000.00  
s\_1 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00  
From ((5.A5), TBDY), TBDY: cc = 0.00204062

$c = \text{confinement factor} = 1.00406$   
 $y1 = 0.00120915$   
 $sh1 = 0.00467215$   
 $ft1 = 348.235$   
 $fy1 = 290.1959$   
 $su1 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.31638566$   
 $su1 = 0.4 * esu1\_nominal ((5.5), \text{TBDY}) = 0.03226667$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08066667$ ,  
 For 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  $fs1 = fs = 290.1959$   
 with  $Es1 = Es = 200000.00$   
 $y2 = 0.00120915$   
 $sh2 = 0.00467215$   
 $ft2 = 348.235$   
 $fy2 = 290.1959$   
 $su2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/lb,min = 0.31638566$   
 $su2 = 0.4 * esu2\_nominal ((5.5), \text{TBDY}) = 0.03226667$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08066667$ ,  
 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  $fs2 = fs = 290.1959$   
 with  $Es2 = Es = 200000.00$   
 $yv = 0.00120915$   
 $shv = 0.00467215$   
 $ftv = 348.235$   
 $fyv = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv\_nominal ((5.5), \text{TBDY}) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 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  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07029503$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.07029503$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01510726$   
 and confined core properties:  
 $b = 190.00$   
 $d = 2927.00$   
 $d' = 13.00$   
 $fcc (5A.2, \text{TBDY}) = 16.06499$   
 $cc (5A.5, \text{TBDY}) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09344146$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.09344146$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02008172$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

$$su(4.9) = 0.14318411$$

$$Mu = MRc(4.14) = 3.0413E+009$$

$$u = su(4.1) = 2.2880917E-006$$

-----  
Calculation of ratio lb/ld

-----  
Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$db = 16.85714$$

$$\text{Mean strength value of all re-bars: } fy = 500.00$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 2.24399$$

$$n = 28.00$$

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

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

$$u = 2.2735554E-006$$

$$Mu = 2.8453E+009$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$fc = 16.00$$

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

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

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

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

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

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

-----  
 $fx = 0.00$

$$af = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$bw = 250.00$$

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

-----  
 $fy = 0.00$

$$af = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$bw = 3000.00$$

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

-----  
 $R = 40.00$

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

$$fu,f = 1055.00$$

$$Ef = 64828.00$$

$$u,f = 0.015$$

$$ase((5.4d), TBDY) = (ase1 \cdot Acol1 + ase2 \cdot Acol2 + ase3 \cdot Aweb) / Asec = 0.00$$

$$ase1 = 0.00$$

$$sh_1 = 150.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$ase2 = 0.00$$

$$sh_2 = 150.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$ase3 = 0 \text{ (grid does not provide confinement)}$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$$

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

$$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$$

$$ps1,x \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.00083776$$

$$h1 = 600.00$$

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

No stirrups, ns1 = 2.00

$$ps2,x \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.00083776$$

$$h2 = 600.00$$

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

No stirrups, ns2 = 2.00

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

$$h3 = 1800.00$$

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

No stirrups, ns3 = 2.00

$$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$$

$$ps1,y \text{ (column 1)} = (As1 \cdot h1 / s_1) / Ac = 0.00034907$$

$$h1 = 250.00$$

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

No stirrups, ns1 = 2.00

$$ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

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

No stirrups, ns2 = 2.00

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

$$h3 = 250.00$$

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

No stirrups, ns3 = 0.00

$$Asec = 750000.00$$

$$s_1 = 150.00$$

$$s_2 = 150.00$$

$$s_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

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

$$lo/lou,min = lb/d = 0.31638566$$

$$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08066667,$$

For 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.

$$\text{with } fs1 = fs = 290.1959$$

with  $E_s1 = E_s = 200000.00$   
 $y_2 = 0.00120915$   
 $sh_2 = 0.00467215$   
 $ft_2 = 348.235$   
 $fy_2 = 290.1959$   
 $su_2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/lb_{u,min} = 0.31638566$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08066667$ ,  
 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  $fs_2 = fs = 290.1959$   
 with  $E_s2 = E_s = 200000.00$   
 $y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348.235$   
 $fy_v = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08066667$ ,  
 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  $fsv = fs = 290.1959$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.07029503$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.07029503$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.00$   
 and confined core properties:  
 $b = 190.00$   
 $d = 2927.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.09344146$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.09344146$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.00$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.13770595$   
 $Mu = MRc (4.14) = 2.8453E+009$   
 $u = su (4.1) = 2.2735554E-006$

#### Calculation of ratio $lb/ld$

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb_{u,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$

s = 0.80  
e = 1.00  
cb = 25.00  
Ktr = 2.24399  
n = 28.00

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

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

u = 2.2880917E-006  
Mu = 3.0413E+009

-----  
with full section properties:

b = 250.00  
d = 2957.00  
d' = 43.00  
v = 0.00232618  
N = 27514.027

fc = 16.00

co (5A.5, TBDY) = 0.002

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

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

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

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

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

-----  
 $\phi_{fx} = 0.00$

$\text{af} = 0.00$

b = 250.00

h = 3000.00

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

bw = 250.00

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

-----  
 $\phi_{fy} = 0.00$

$\text{af} = 0.00$

b = 3000.00

h = 250.00

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

bw = 3000.00

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

-----  
R = 40.00

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

$\text{fu},f = 1055.00$

$\text{Ef} = 64828.00$

$\text{u},f = 0.015$

$\text{ase}$  ((5.4d), TBDY) =  $(\text{ase1} * \text{Acol1} + \text{ase2} * \text{Acol2} + \text{ase3} * \text{Aweb}) / \text{Asec} = 0.00$

$\text{ase1} = 0.00$

sh\_1 = 150.00

bo\_1 = 190.00

ho\_1 = 540.00

bi2\_1 = 655400.00

$\text{ase2} = 0.00$

sh\_2 = 150.00

bo\_2 = 190.00

ho\_2 = 540.00

bi2\_2 = 655400.00

$\text{ase3} = 0$  (grid does not provide confinement)

$\text{psh},\text{min} = \text{Min}(\text{psh},x, \text{psh},y) = 0.00069813$

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

psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
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 = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/l\_d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

lo/lou,min = lb/l\_b,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with  $E_s = E_s = 200000.00$   
 $y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348.235$   
 $fy_v = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07029503$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.07029503$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01510726$   
 and confined core properties:  
 $b = 190.00$   
 $d = 2927.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09344146$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.09344146$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02008172$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.24399$   
 $n = 28.00$

-----

Calculation of Shear Strength  $V_r = Min(V_{r1}, V_{r2}) = 1.9920E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920E+006$   
 From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r1} = V_n < 0.83 * fc' ^{0.5} * h * d$

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

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

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

= 1 (normal-weight concrete)

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

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 2.8012401E-010$

$V_u = 6.3108872E-029$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$V_{s3} = 452389.342$  is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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:  $\theta = b_1 + 90^\circ = 90.00$

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

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

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

$b_w = 250.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920E+006$

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

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

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

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

= 1 (normal-weight concrete)

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

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 2.8012401E-010$

$V_u = 6.3108872E-029$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$

Av = 157079.633

s = 150.00

fy = 400.00

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

Vs2 = 201061.93 is calculated for pseudo-Column 2, with:

d = 480.00

Av = 157079.633

s = 150.00

fy = 400.00

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

Vs3 = 452389.342 is calculated for web, with:

d = 1440.00

Av = 157079.633

s = 200.00

fy = 400.00

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

orientation 1:  $\theta = 45^\circ$

Vf = Min(|Vf(45,  $\theta$ )|, |Vf(-45,  $\theta$ )|), with:

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

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:  $Vs + Vf \leq 1.5943E+006$

bw = 250.00

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

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

Constant Properties

-----  
Knowledge Factor,  $\phi = 0.85$

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

Consequently:

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

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####

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 = 1.00406

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
FRP Wrapping Data  
Type: Carbon  
Cured laminate properties (design values)  
Thickness,  $t = 1.016$   
Tensile Strength,  $f_{fu} = 1055.00$   
Tensile Modulus,  $E_f = 64828.00$   
Elongation,  $e_{fu} = 0.01$   
Number of directions,  $NoDir = 1$   
Fiber orientations,  $b_i = 0.00^\circ$   
Number of layers,  $NL = 1$   
Radius of rounding corners,  $R = 40.00$

#### Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 0.00$   
EDGE -B-  
Shear Force,  $V_b = 0.00$   
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,  $V_e/V_r = 0.14054053$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7738E+008$   
 $Mu_{1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7738E+008$   
 $Mu_{2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $Mu_{2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

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

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 3.4223799E-005$   
 $Mu = 1.4516E+008$

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$a_{se1} = 0.00$$

$$s_{h,1} = 150.00$$

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

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

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

$$a_{se2} = 0.00$$

$$s_{h,2} = 150.00$$

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

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

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

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

$$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

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

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00083776$$

$$h_1 = 600.00$$

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

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

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00083776$$

$$h_2 = 600.00$$

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

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

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

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

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

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00034907$$

$$h_1 = 250.00$$

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

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

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00034907$$

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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$   
 and confined core properties:  
 $b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08209659$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08209659$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18563201$   
 $Mu = MRc (4.14) = 1.4516E+008$   
 $u = su (4.1) = 3.4223799E-005$

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

Lap Length:  $l_b/l_d = 0.31638566$   
 $l_b = 300.00$   
 $l_d = 948.2098$   
 Calculation of  $l_b,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $f_y = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.24399$   
 $n = 28.00$

-----  
 Calculation of  $Mu1$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 3.5153739E-005$   
 $Mu = 1.7738E+008$   
 -----

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  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, cc) = 0.0035$   
 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),  $f_{f,e} = 636.1644$

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_f = 0.015$

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

$a_{se1} = 0.00$

$sh_{_1} = 150.00$

$bo_{_1} = 190.00$

$ho_{_1} = 540.00$

$bi_{2\_1} = 655400.00$

$a_{se2} = 0.00$

$sh_{_2} = 150.00$

$bo_{_2} = 190.00$

$ho_{_2} = 540.00$

$bi_{2\_2} = 655400.00$

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

$p_{sh,min} = \min(p_{sh,x}, p_{sh,y}) = 0.00069813$

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

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} \cdot h_1 / s_1) / A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} \cdot h_2 / s_2) / A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

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

$h_3 = 1800.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} \cdot h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} \cdot h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3} \cdot h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$

No stirrups,  $n_{s3} = 0.00$

$A_{sec} = 750000.00$

$s_{_1} = 150.00$

$s_{_2} = 150.00$

$s_{_3} = 200.00$

$f_{ywe} = 500.00$

$f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$

$c$  = confinement factor = 1.00406

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/d = 0.31638566$   
 $su_1 = 0.4 * esu_1,nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_1,nominal = 0.08066667$ ,  
 For calculation of  $esu_1,nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = fs = 290.1959$   
 with  $Es_1 = Es = 200000.00$

$y_2 = 0.00120915$   
 $sh_2 = 0.00467215$   
 $ft_2 = 348.235$   
 $fy_2 = 290.1959$   
 $su_2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/lb,min = 0.31638566$   
 $su_2 = 0.4 * esu_2,nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_2,nominal = 0.08066667$ ,  
 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  $Min(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = fs = 290.1959$   
 with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348.235$   
 $fy_v = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/d = 0.31638566$   
 $suv = 0.4 * esuv,nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv,nominal = 0.08066667$ ,  
 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  $Min(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$

$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.06885062$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.06885062$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04675268$

and confined core properties:

$b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.08209659$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.08209659$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.05574729$

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

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

su (4.9) = 0.20717489  
Mu = MRc (4.14) = 1.7738E+008  
u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Lap Length: lb/l<sub>d</sub> = 0.31638566

lb = 300.00

l<sub>d</sub> = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 2.24399

n = 28.00

-----  
-----  
Calculation of Mu<sub>2+</sub>

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

u = 3.4223799E-005

Mu = 1.4516E+008

-----  
with full section properties:

b = 3000.00

d = 208.00

d' = 42.00

v = 0.00275581

N = 27514.027

f<sub>c</sub> = 16.00

co (5A.5, TBDY) = 0.002

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

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

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

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

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

-----  
f<sub>x</sub> = 0.00

af = 0.00

b = 250.00

h = 3000.00

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

b<sub>w</sub> = 250.00

effective stress from (A.35), ff,e = 636.1644

-----  
f<sub>y</sub> = 0.00

af = 0.00

b = 3000.00

h = 250.00

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

b<sub>w</sub> = 3000.00

effective stress from (A.35), ff,e = 944.3987

-----  
R = 40.00

Effective FRP thickness, t<sub>f</sub> =  $NL * t * \text{Cos}(b_1) = 1.016$

f<sub>u,f</sub> = 1055.00

E<sub>f</sub> = 64828.00

u<sub>f</sub> = 0.015

ase ((5.4d), TBDY) =  $(\text{ase}_1 * A_{col1} + \text{ase}_2 * A_{col2} + \text{ase}_3 * A_{web}) / A_{sec} = 0.00$

ase1 = 0.00  
sh\_1 = 150.00  
bo\_1 = 190.00  
ho\_1 = 540.00  
bi2\_1 = 655400.00

ase2 = 0.00  
sh\_2 = 150.00  
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) = 0.00069813

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

psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
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 = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

$y_2 = 0.00120915$   
 $sh_2 = 0.00467215$   
 $ft_2 = 348.235$   
 $fy_2 = 290.1959$   
 $su_2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/lb_{min} = 0.31638566$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08066667$ ,  
 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  $fs_2 = fs = 290.1959$   
 with  $Es_2 = Es = 200000.00$   
 $y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348.235$   
 $fy_v = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08066667$ ,  
 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  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.06885062$   
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.06885062$   
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$

and confined core properties:

$b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.08209659$   
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.08209659$   
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$

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

--->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18563201$   
 $Mu = MRc (4.14) = 1.4516E+008$   
 $u = su (4.1) = 3.4223799E-005$

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

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$

e = 1.00  
cb = 25.00  
Ktr = 2.24399  
n = 28.00

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

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

$\mu = 3.5153739E-005$   
Mu = 1.7738E+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  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu, \mu_c) = 0.0035$

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

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

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

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),  $f_{f,e} = 636.1644$

-----  
 $f_y = 0.00$

$a_f = 0.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f} = 0.015$

$\text{ase}$  ((5.4d), TBDY) =  $(\text{ase}_1 * A_{col1} + \text{ase}_2 * A_{col2} + \text{ase}_3 * A_{web}) / A_{sec} = 0.00$

$\text{ase}_1 = 0.00$

sh\_1 = 150.00

bo\_1 = 190.00

ho\_1 = 540.00

bi2\_1 = 655400.00

$\text{ase}_2 = 0.00$

sh\_2 = 150.00

bo\_2 = 190.00

ho\_2 = 540.00

bi2\_2 = 655400.00

$\text{ase}_3 = 0$  (grid does not provide confinement)

$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

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

-----  
 $p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

ps1,x (column 1) =  $(As1 \cdot h1 / s_1) / Ac = 0.00083776$   
h1 = 600.00  
As1 = Astir1 \* ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) =  $(As2 \cdot h2 / s_2) / Ac = 0.00083776$   
h2 = 600.00  
As2 = Astir2 \* ns2 = 157.0796  
No stirups, ns2 = 2.00  
ps3,x (web) =  $(As3 \cdot h3 / s_3) / Ac = 0.00188496$   
h3 = 1800.00  
As3 = Astir3 \* ns3 = 0.00  
No stirups, ns3 = 2.00

psh,y = ps1,y + ps2,y + ps3,y = 0.00069813  
ps1,y (column 1) =  $(As1 \cdot h1 / s_1) / Ac = 0.00034907$   
h1 = 250.00  
As1 = Astir1 \* ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) =  $(As2 \cdot h2 / s_2) / Ac = 0.00034907$   
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00

fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4 \* esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4 \* esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

$y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348,235$   
 $fy_v = 290,1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 290,1959$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.06885062$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.06885062$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04675268$   
 and confined core properties:  
 $b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.08209659$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.08209659$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.05574729$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.20717489$   
 $Mu = MRc (4.14) = 1.7738E+008$   
 $u = su (4.1) = 3.5153739E-005$

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

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.24399$   
 $n = 28.00$

-----  
 Calculation of Shear Strength  $Vr = Min(Vr1, Vr2) = 841398.394$   
 -----

Calculation of Shear Strength at edge 1,  $Vr1 = 841398.394$   
 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:  $V_c = 653502.805$

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

= 1 (normal-weight concrete)

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

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 1.9099438E-011$

$V_u = 0.00$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$2(1-s/d) = 0.50$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$2(1-s/d) = 0.50$

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

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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  $V_f(\theta, a)$ , is implemented for every different cyclic fiber orientation  $a_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = 45^\circ$  and  $a = 90^\circ$

$V_f = \text{Min}(|V_f(45, 90)|, |V_f(-45, 90)|)$ , with:

total thickness per orientation,  $t_f = N_L * t / N_{Dir} = 1.016$

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

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

$E_f = 64828.00$

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

with  $f_u = 0.01$

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

$b_w = 3000.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 841398.394$

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

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

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

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

= 1 (normal-weight concrete)

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

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 1.9099438E-011$

$V_u = 0.00$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

Vs1 = 41887.902 is calculated for pseudo-Column 1, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$$2(1-s/d) = 0.50$$

Vs2 = 41887.902 is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$$2(1-s/d) = 0.50$$

Vs3 = 0.00 is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 400.00$$

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

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

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

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

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

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

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

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

orientation 1:  $\theta = b_1 + 90^\circ = 90.00$

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

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

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

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

$$E_f = 64828.00$$

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

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

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

$$b_w = 3000.00$$

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

At local axis: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rcrws

Constant Properties

-----  
Knowledge Factor,  $\phi = 0.85$

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

$$\rho_n = 0.00069813$$

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

$$\text{(pseudo-col.1 } \rho_{s1} = A_{s1} * b_1 / s_1 = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$$

$$h_1 = 250.00$$

$$s_1 = 150.00$$

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

$$\text{(pseudo-col.2 } \rho_{s2} = A_{s2} * b_2 / s_2 = (A_{s2} * h_2 / s_2) / A_c = 0.00034907$$

$$h_2 = 250.00$$

$$s_2 = 150.00$$

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

(grid ps3 =  $As3 \cdot b3 / s3 = (As3 \cdot h3 / s3) / Ac = 0.00$   
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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_b = 300.00$   
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,  $F = -29773.887$   
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:  $As_{l,ten} = 2865.133$   
-Compression:  $As_{l,com} = 2865.133$   
-Middle:  $As_{l,mid} = 615.7522$   
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:  $u = 0.00470588$

with:

- Condition i (shear wall and wall segments)  
-  $(As - As') \cdot f_y + P) / (tw \cdot lw \cdot f_c) = -0.20905275$   
 $As = 0.00$   
 $As' = 6346.017$   
 $f_y = 400.00$   
 $P = 29773.887$   
 $tw = 250.00$   
 $lw = 3000.00$   
 $f_c = 16.00$

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

---

## Calculation No. 7

wall W1, Floor 1  
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity  $V_{Rd}$   
Edge: End  
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1  
At local axis: 3  
Integration Section: (d)  
Section Type: rcrws

Constant Properties

---

Knowledge Factor,  $\gamma = 0.85$   
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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

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,  $M_a = 1.0286E+008$

Shear Force,  $V_a = -34419.312$

EDGE -B-

Bending Moment,  $M_b = 420173.225$

Shear Force,  $V_b = 34419.312$

BOTH EDGES

Axial Force,  $F = -29773.887$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle:  $A_{st,mid} = 615.7522$

Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 17.33333$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = V_n = 1.6932E+006$

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:  $V_c = 653954.777$

$\mu_u / \nu_u - l_w / 2 = -1487.793 \leq 0$

= 1 (normal-weight concrete)

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

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$M_u = 420173.225$

$V_u = 34419.312$

$N_u = 29773.887$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$$s = 150.00$$

$$f_y = 400.00$$

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

Vs3 = 452389.342 is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

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

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

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

$w_f/s_f = 1$  (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  $\theta$  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  $\alpha_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

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

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

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

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

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

$$E_f = 64828.00$$

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

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

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

$$b_w = 250.00$$

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

At local axis: 3

Integration Section: (d)  
-----

## Calculation No. 8

wall W1, Floor 1

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

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####  
 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 = 1.00406  
 Element Length,  $L = 3000.00$

Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Lap Length  $l_o = 300.00$   
 FRP Wrapping Data  
 Type: Carbon  
 Cured laminate properties (design values)  
 Thickness,  $t = 1.016$   
 Tensile Strength,  $f_{fu} = 1055.00$   
 Tensile Modulus,  $E_f = 64828.00$   
 Elongation,  $e_{fu} = 0.01$   
 Number of directions,  $NoDir = 1$   
 Fiber orientations,  $b_i: 0.00^\circ$   
 Number of layers,  $NL = 1$   
 Radius of rounding corners,  $R = 40.00$

-----  
 Stepwise Properties

-----  
 At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = 6.3108872E-029$   
 EDGE -B-  
 Shear Force,  $V_b = -6.3108872E-029$

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,  $V_e/V_r = 1.01783$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.0413E+009$

$M_{u1+} = 2.8453E+009$ , 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

$M_{u1-} = 3.0413E+009$ , 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.0413E+009$

$M_{u2+} = 2.8453E+009$ , 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

$M_{u2-} = 3.0413E+009$ , 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  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.2735554E-006$

$M_u = 2.8453E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00232618$

$N = 27514.027$

$f_c = 16.00$

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

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)

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

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

where  $\phi = \alpha_f * \phi_{pf} * f_{fe} / f_{ce}$  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,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$   
 $ase_1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $ase_2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$   
 $ase_3 = 0$  (grid does not provide confinement)  
 $psh_{,min} = \min(psh_{,x}, psh_{,y}) = 0.00069813$

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

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x}$  (column 1) =  $(As_1 \cdot h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x}$  (column 2) =  $(As_2 \cdot h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x}$  (web) =  $(As_3 \cdot h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $As_3 = Astir_3 \cdot ns_3 = 0.00$   
 No stirrups,  $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y}$  (column 1) =  $(As_1 \cdot h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y}$  (column 2) =  $(As_2 \cdot h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y}$  (web) =  $(As_3 \cdot h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$   
 No stirrups,  $ns_3 = 0.00$

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$

$f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c =$  confinement factor = 1.00406

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $l_o / l_{ou,min} = l_b / l_d = 0.31638566$

$$su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_1\_nominal = 0.08066667$ ,

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

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

with  $fs_1 = fs = 290.1959$

with  $Es_1 = Es = 200000.00$

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$su_2 = 0.00579712$$

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

$$lo/lo_{u,min} = lb/lb_{min} = 0.31638566$$

$$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_2\_nominal = 0.08066667$ ,

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

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

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

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

$$lo/lo_{u,min} = lb/ld = 0.31638566$$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.07029503$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.07029503$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.09344146$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.09344146$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

Calculation of ratio  $lb/ld$

$$\text{Lap Length: } lb/ld = 0.31638566$$

$$lb = 300.00$$

ld = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.24399

n = 28.00

Calculation of Mu1-

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

$\phi_u = 2.2880917E-006$

Mu = 3.0413E+009

with full section properties:

b = 250.00

d = 2957.00

d' = 43.00

v = 0.00232618

N = 27514.027

fc = 16.00

co (5A.5, TBDY) = 0.002

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)

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

$\phi_{we}$  ((5.4c), TBDY) =  $\text{ase} * \text{sh}_{\min} * \text{fy}_{we} / \text{f}_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi_x = \text{af} * \text{pf} * \text{ff}_{e} / \text{f}_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.00$

af = 0.00

b = 250.00

h = 3000.00

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

$b_w = 250.00$

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

$\phi_y = 0.00$

af = 0.00

b = 3000.00

h = 250.00

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

$b_w = 3000.00$

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

R = 40.00

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

ase ((5.4d), TBDY) =  $(\text{ase}_1 * A_{col1} + \text{ase}_2 * A_{col2} + \text{ase}_3 * A_{web}) / A_{sec} = 0.00$

ase1 = 0.00

sh\_1 = 150.00

bo\_1 = 190.00

ho\_1 = 540.00

bi2\_1 = 655400.00

ase2 = 0.00

sh\_2 = 150.00

bo\_2 = 190.00

ho\_2 = 540.00

$$bi2\_2 = 655400.00$$

ase3 = 0 (grid does not provide confinement)

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$$

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

$$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$$

$$ps1,x \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00083776$$

$$h1 = 600.00$$

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

No stirrups, ns1 = 2.00

$$ps2,x \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00083776$$

$$h2 = 600.00$$

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

No stirrups, ns2 = 2.00

$$ps3,x \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00188496$$

$$h3 = 1800.00$$

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

No stirrups, ns3 = 2.00

$$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$$

$$ps1,y \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00034907$$

$$h1 = 250.00$$

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

No stirrups, ns1 = 2.00

$$ps2,y \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

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

No stirrups, ns2 = 2.00

$$ps3,y \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00$$

$$h3 = 250.00$$

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

No stirrups, ns3 = 0.00

$$Asec = 750000.00$$

$$s\_1 = 150.00$$

$$s\_2 = 150.00$$

$$s\_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

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

$$lo/lou,min = lb/l_d = 0.31638566$$

$$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

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

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

with fs1 = fs = 290.1959

with Es1 = Es = 200000.00

$$y2 = 0.00120915$$

$$sh2 = 0.00467215$$

$$ft2 = 348.235$$

$$fy2 = 290.1959$$

$$su2 = 0.00579712$$

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

$$lo/lou,min = lb/l_b,min = 0.31638566$$

$$su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08066667$ ,

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

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

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

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

$$lo/lo_{u,min} = lb/ld = 0.31638566$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08066667$ ,

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

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

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

with  $fsv = fs = 290.1959$

with  $Es_v = Es = 200000.00$

$$1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.07029503$$

$$2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.07029503$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.01510726$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.09344146$$

$$2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.09344146$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.02008172$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.14318411$$

$$\mu_u = MR_c (4.14) = 3.0413E+009$$

$$u = su (4.1) = 2.2880917E-006$$

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

-----  
Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $\mu_{u2+}$

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

$$u = 2.2735554E-006$$

$$\mu = 2.8453E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

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

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

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

$$\phi_{fx} = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

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

$$b_w = 250.00$$

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

$$\phi_{fy} = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

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

$$b_w = 3000.00$$

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

$$R = 40.00$$

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

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

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

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

$$\alpha_{se1} = 0.00$$

$$sh_{,1} = 150.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

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

$$\alpha_{se2} = 0.00$$

$$sh_{,2} = 150.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

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

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

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

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

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

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

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

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

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

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

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

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

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00

fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

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

lo/lou,min = lb/l\_d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

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

with fs1 = fs = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

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

lo/lou,min = lb/l\_b,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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

with fs2 = fs = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

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

lo/lou,min = lb/l\_d = 0.31638566

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07029503$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07029503$$

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

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$c =$  confinement factor = 1.00406

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09344146$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09344146$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 2.24399$$

$$n = 28.00$$

Calculation of  $Mu2$ -

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

$$u = 2.2880917E-006$$

$$Mu = 3.0413E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$fc = 16.00$$

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

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

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

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

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

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)

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

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

$bw = 250.00$

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

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

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

$bw = 3000.00$

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

$R = 40.00$

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

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

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

$a_{se1} = 0.00$

$s_{h,1} = 150.00$

$b_{o,1} = 190.00$

$h_{o,1} = 540.00$

$b_{i2,1} = 655400.00$

$a_{se2} = 0.00$

$s_{h,2} = 150.00$

$b_{o,2} = 190.00$

$h_{o,2} = 540.00$

$b_{i2,2} = 655400.00$

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

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

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

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

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

$h_3 = 1800.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$

No stirups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

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

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

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

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07029503

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07029503

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01510726

and confined core properties:

b = 190.00

d = 2927.00

d' = 13.00

fcc (5A.2, TBDY) = 16.06499

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = \text{Asl,ten}/(b*d)*(fs1/fc) = 0.09344146$$

$$2 = \text{Asl,com}/(b*d)*(fs2/fc) = 0.09344146$$

$$v = \text{Asl,mid}/(b*d)*(fsv/fc) = 0.02008172$$

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

--->

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

--->

$$su (4.9) = 0.14318411$$

$$Mu = MRc (4.14) = 3.0413E+009$$

$$u = su (4.1) = 2.2880917E-006$$

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

-----  
Lap Length:  $l_b/l_d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \text{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.9920E+006$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r1} = V_n < 0.83*fc'^{0.5}*h*d$

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

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

$$Mu/V_u - l_w/2 = 0.00 <= 0$$

= 1 (normal-weight concrete)

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

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$Mu = 2.8012401E-010$$

$$V_u = 6.3108872E-029$$

$$Nu = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

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

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

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

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

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|), \text{ with:}$$

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

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

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

$$E_f = 64828.00$$

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

with  $f_u = 0.01$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 250.00$$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920E+006$

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) 'Vw' is replaced by 'Vw + f \* V\_f'  
where V\_f is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$

$$\mu_u / \nu_u - l_w / 2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$f_c' = 16.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$\mu_u = 2.8012401E-010$$

$$\nu_u = 6.3108872E-029$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

Vs1 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

Vs2 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

Vs3 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 1.5581E+006$$

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|), \text{ with:}$$

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  
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 = 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,  $\gamma = 0.85$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$   
#####  
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 = 1.00406  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
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,  $V_a = 0.00$   
EDGE -B-  
Shear Force,  $V_b = 0.00$   
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:  $As_{,ten} = 2368.761$   
-Compression:  $As_{,com} = 2368.761$   
-Middle:  $As_{,mid} = 0.00$   
(According to 10.7.2.3  $As_{,mid}$  is setted equal to zero)

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.14054053$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7738E+008$   
 $Mu_{1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7738E+008$   
 $Mu_{2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $Mu_{2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 3.4223799E-005$   
 $M_u = 1.4516E+008$

with full section properties:

$b = 3000.00$   
 $d = 208.00$   
 $d' = 42.00$   
 $v = 0.00275581$   
 $N = 27514.027$   
 $f_c = 16.00$   
 $\alpha_1(5A.5, \text{TBDY}) = 0.002$

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)

From (5.4b), TBDY:  $\phi_u = 0.0035$

where  $\phi_u = \alpha_1 \phi_{u,FRP} + \alpha_2 \phi_{u,con}$  (5.4c), TBDY) =  $\alpha_1 \phi_{u,FRP} + \alpha_2 \phi_{u,con} = 0.00$

where  $\phi_{u,FRP} = \alpha_1 \phi_{u,FRP} = \alpha_1 \phi_{u,FRP} = \alpha_1 \phi_{u,FRP}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_{u,FRP} = 0.00$

$\alpha_1 = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $\phi_{u,FRP} = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35),  $\phi_{u,FRP} = 636.1644$

$\phi_{u,con} = 0.00$

$\alpha_2 = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $\phi_{u,con} = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $\phi_{u,con} = 944.3987$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 * A_{col1} + ase_2 * A_{col2} + ase_3 * A_{web}) / A_{sec} = 0.00$   
 $ase_1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $ase_2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$   
 $ase_3 = 0$  (grid does not provide confinement)  
 $psh_{,min} = \text{Min}(psh_{,x}, psh_{,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $psh_{,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $As_3 = Astir_3 * ns_3 = 0.00$   
 No stirrups,  $ns_3 = 2.00$

-----

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $As_3 = Astir_3 * ns_3 = 157.0796$   
 No stirrups,  $ns_3 = 0.00$

-----

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $fy_{we} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.31638566$   
 $su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.03226667$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08066667$ ,

For 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  $fs1 = fs = 290.1959$

with  $Es1 = Es = 200000.00$

$y2 = 0.00120915$

$sh2 = 0.00467215$

$ft2 = 348.235$

$fy2 = 290.1959$

$su2 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 0.31638566$

$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08066667$ ,

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  $fs2 = fs = 290.1959$

with  $Es2 = Es = 200000.00$

$yv = 0.00120915$

$shv = 0.00467215$

$ftv = 348.235$

$fyv = 290.1959$

$suv = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.31638566$

$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.06885062$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.06885062$

$v = Asl, mid / (b * d) * (fsv / fc) = 0.00$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$fcc (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c =$  confinement factor  $= 1.00406$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.08209659$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.08209659$

$v = Asl, mid / (b * d) * (fsv / fc) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < vs, y2$  - LHS eq.(4.5) is satisfied

---

$su (4.9) = 0.18563201$

$Mu = MRc (4.14) = 1.4516E+008$

$u = su (4.1) = 3.4223799E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $I_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$d_b = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 3.5153739E-005$

$\mu = 1.7738E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu, \mu_c) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.0035$

$\mu_{we}$  ((5.4c), TBDY) =  $\alpha \cdot \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \alpha * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35),  $f_{fe} = 636.1644$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $f_{fe} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_{,2} = 150.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

ase3 = 0 (grid does not provide confinement)  
psh,min = Min(psh,x , psh,y) = 0.00069813  
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
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 = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00  
From ((5.A5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406  
y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_d = 0.31638566  
su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667  
From table 5A.1, TBDY: esu1\_nominal = 0.08066667,  
For 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 = 290.1959  
with Es1 = Es = 200000.00  
y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_b,min = 0.31638566  
su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $es_{u2\_nominal} = 0.08066667$ ,

For calculation of  $es_{u2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$

$sh_v = 0.00467215$

$ft_v = 348.235$

$fy_v = 290.1959$

$s_{uv} = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.31638566$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $es_{uv\_nominal} = 0.08066667$ ,

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_v = fs = 290.1959$

with  $Es_v = Es = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.06885062$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.06885062$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.04675268$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$f_{cc} (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c = \text{confinement factor} = 1.00406$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.08209659$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.08209659$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.20717489$

$\mu_u = MR_c (4.14) = 1.7738E+008$

$u = s_u (4.1) = 3.5153739E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$db = 16.85714$

Mean strength value of all re-bars:  $fy = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

-----  
Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$\alpha (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0035$$

$$\omega_e \text{ ((5.4c), TBDY) } = \alpha s_e * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$$

where  $\phi = \alpha f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_x = 0.00$$

$$\alpha f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$\phi_y = 0.00$$

$$\alpha f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

$$\alpha s_e \text{ ((5.4d), TBDY) } = (\alpha s_{e1} * A_{col1} + \alpha s_{e2} * A_{col2} + \alpha s_{e3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha s_{e1} = 0.00$$

$$sh_{1} = 150.00$$

$$bo_{1} = 190.00$$

$$ho_{1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$\alpha s_{e2} = 0.00$$

$$sh_{2} = 150.00$$

$$bo_{2} = 190.00$$

$$ho_{2} = 540.00$$

$$bi_{2,2} = 655400.00$$

$$\alpha s_{e3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $p_{sh,\min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1) } = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2) } = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web) } = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
considering characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv, shv,ftv,fyv$ , it is considered  
characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = fs = 290.1959$   
with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.06885062$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.06885062$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.00$

and confined core properties:

$b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $fcc$  (5A.2, TBDY) = 16.06499  
 $cc$  (5A.5, TBDY) = 0.00204062  
 $c =$  confinement factor = 1.00406  
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.08209659$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08209659$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied

--->  
 $su$  (4.9) = 0.18563201  
 $Mu = MRc$  (4.14) = 1.4516E+008  
 $u = su$  (4.1) = 3.4223799E-005

-----  
Calculation of ratio  $lb/ld$

-----  
Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$   
 $ld = 948.2098$

Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$db = 16.85714$   
Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.24399$   
 $n = 28.00$

-----  
Calculation of  $Mu2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 3.5153739E-005$   
 $Mu = 1.7738E+008$

-----  
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:  $cu = 0.0035$

$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$   
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),  $p_f = 2t_f/bw = 0.008128$   
 $bw = 250.00$   
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,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$   
 $a_{se1} = 0.00$   
 $s_{h,1} = 150.00$   
 $b_{o,1} = 190.00$   
 $h_{o,1} = 540.00$   
 $b_{i2,1} = 655400.00$   
 $a_{se2} = 0.00$   
 $s_{h,2} = 150.00$   
 $b_{o,2} = 190.00$   
 $h_{o,2} = 540.00$   
 $b_{i2,2} = 655400.00$   
 $a_{se3} = 0$  (grid does not provide confinement)  
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$   
 $p_{s1,x} (\text{column 1}) = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$   
No stirrups,  $n_{s1} = 2.00$   
 $p_{s2,x} (\text{column 2}) = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$   
No stirrups,  $n_{s2} = 2.00$   
 $p_{s3,x} (\text{web}) = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $A_{s3} = A_{stir3} * n_{s3} = 0.00$   
No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$   
 $p_{s1,y} (\text{column 1}) = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $A_{s1} = A_{stir1} * n_{s1} = 157.0796$   
No stirrups,  $n_{s1} = 2.00$   
 $p_{s2,y} (\text{column 2}) = (A_{s2} * h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $A_{s2} = A_{stir2} * n_{s2} = 157.0796$   
No stirrups,  $n_{s2} = 2.00$   
 $p_{s3,y} (\text{web}) = (A_{s3} * h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $A_{s3} = A_{stir3} * n_{s3} = 157.0796$   
No stirrups,  $n_{s3} = 0.00$

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 =  $Asl,ten/(b*d)*(fs1/fc) = 0.08209659$

2 =  $Asl,com/(b*d)*(fs2/fc) = 0.08209659$

v =  $Asl,mid/(b*d)*(fsv/fc) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

v < vs,y2 - LHS eq.(4.5) is satisfied

---

su (4.9) = 0.20717489

Mu = MRc (4.14) = 1.7738E+008

u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

Lap Length: lb/l<sub>d</sub> = 0.31638566

lb = 300.00

l<sub>d</sub> = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 2.24399

n = 28.00

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 841398.394

-----  
Calculation of Shear Strength at edge 1, Vr1 = 841398.394

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 = 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 = 1.9099438E-011

Vu = 0.00

Nu = 27514.027

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 + Vs3 = 83775.804

Vs1 = 41887.902 is calculated for pseudo-Column 1, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs1 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs2 = 41887.902 is calculated for pseudo-Column 2, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs2 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs3 = 0.00 is calculated for web, with:

$d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$   
 Vs3 has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.00$   
 $V_f$  ((11-3)-(11.4), 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  $\theta$  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  $\alpha_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L * t / \text{NoDir} = 1.016$   
 $d_{fv} = d$  (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,  $V_{r2} = 841398.394$   
 From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r2} = V_n < 0.83 * f_c^{0.5} * h * d$

NOTE: In expression (22.5.1.1) ' $V_w$ ' is replaced by ' $V_w + f * V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$   
 $\mu_u / V_u - l_w / 2 = 0.00 \leq 0$   
 $= 1$  (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 3000.00$   
 $d = 200.00$   
 $l_w = 250.00$   
 $\mu_u = 1.9099438E-011$   
 $V_u = 0.00$   
 $N_u = 27514.027$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$   
 $V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s3} = 0.00$  is calculated for web, with:  
 $d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$   
 $V_{s3}$  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  $\theta$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $\theta_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$  (figure 11.2, ACI 440) = 208.00

$f_{fe}$  ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.01$

From (11-11), ACI 440:  $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

-----  
End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (d)

Section Type: rcrws

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.85$

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

$\rho_n = 0.00069813$

-----  
with  $\rho_n = \rho_{s1} + \rho_{s2} + \rho_{s3}$ , being the shear reinf. ratio in a plane perpendicular to the shear axis 2

(pseudo-col.1  $\rho_{s1} = A_{s1} \cdot b_1 / s_1 = (A_{s1} \cdot h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$s_1 = 150.00$

total area of hoops perpendicular to shear axis,  $A_{s1} = 157.0796$

(pseudo-col.2  $\rho_{s2} = A_{s2} \cdot b_2 / s_2 = (A_{s2} \cdot h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$s_2 = 150.00$

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at  $135^\circ$ )

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

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

Bending Moment,  $M = 7.0728943E-011$   
Shear Force,  $V_2 = 7.6985341E-015$   
Shear Force,  $V_3 = 34419.312$   
Axial Force,  $F = -29773.887$   
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:  $As_{,ten} = 2368.761$   
-Compression:  $As_{,com} = 2368.761$   
-Middle:  $As_{,mid} = 1608.495$   
Mean Diameter of Tension Reinforcement,  $DbL = 17.20$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = u = 0.00277127$   
 $u = y + p = 0.00326031$

- Calculation of  $y$  -

$y = (My * I_p) / (EI)_{Eff} = 0.00126031$  ((10-5), ASCE 41-17))  
 $My = 1.5091E+008$   
 $(EI)_{Eff} = 0.35 * E_c * I$  (table 10-5)  
 $E_c * I = 8.2106E+013$   
 $I_p = 0.5 * d = 0.5 * (0.8 * h) = 240.00$

Calculation of Yielding Moment  $My$

Calculation of  $y$  and  $My$  according to Annex 7 -

$y = \text{Min}(y_{,ten}, y_{,com})$   
 $y_{,ten} = 8.7656668E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 269.394$   
 $d = 208.00$   
 $y = 0.26122943$   
 $A = 0.01034702$   
 $B = 0.00628884$   
with  $pt = 0.00379609$   
 $pc = 0.00379609$   
 $pv = 0.00257772$   
 $N = 29773.887$   
 $b = 3000.00$   
 $" = 0.20192308$   
 $y_{,comp} = 2.5442941E-005$   
with  $f_c^*$  (12.3, (ACI 440)) = 16.002  
 $f_c = 16.00$   
 $f_l = 0.17503396$   
 $b = 3000.00$   
 $h = 250.00$   
 $Ag = 750000.00$   
From (12.9), ACI 440:  $ka = 0.00364754$

$$g = p_t + p_c + p_v = 0.0101699$$

$$r_c = 40.00$$

$$A_e/A_c = 0.52524587$$

$$\text{Effective FRP thickness, } t_f = N_L * t * \cos(\theta_1) = 1.016$$

$$\text{effective strain from (12.5) and (12.12), } \epsilon_{fe} = 0.004$$

$$f_u = 0.01$$

$$E_f = 64828.00$$

$$E_c = 21019.039$$

$$y = 0.25894248$$

$$A = 0.0099958$$

$$B = 0.00611172$$

$$\text{with } E_s = 200000.00$$

-----  
-----  
Calculation of ratio  $I_b/I_d$

$$\text{Lap Length: } I_d/I_{d,\min} = 0.39548208$$

$$I_b = 300.00$$

$$I_d = 758.5679$$

Calculation of  $I$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

$$\text{Mean strength value of all re-bars: } f_y = 400.00$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
- Calculation of  $p$  -

-----  
Considering wall controlled by flexure (shear control ratio  $\leq 1$ ),

from table 10-19:  $p = 0.002$

with:

- Condition i (shear wall and wall segments)

$$-(A_s - A_s') * f_y + P / (t_w * I_w * f_c') = -0.20905275$$

$$A_s = 0.00$$

$$A_s' = 6346.017$$

$$f_y = 400.00$$

$$P = 29773.887$$

$$t_w = 3000.00$$

$$I_w = 250.00$$

$$f_c = 16.00$$

$$-V / (t_w * I_w * f_c^{0.5}) = 3.0903667E-020, \text{ NOTE: units in lb \& in}$$

- Confined Boundary: No

Boundary hoops spacing exceed  $8d_b$  ( $s_1 > 8 * d_b$  or  $s_2 > 8 * d_b$ )

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:

$$V_{w1} = 83775.804$$

$$s_1 = 150.00$$

Boundary Element 2:

$$V_{w2} = 83775.804$$

$$s_2 = 150.00$$

$$\text{Grid Shear Force, } V_{w3} = 0.00$$

$$\text{Concrete Shear Force, } V_c = 126752.235$$

(The variables above have already been given in Shear control ratio calculation)

$$\text{Mean diameter of all bars, } d_b = 17.33333$$

$$\text{Design Shear Force, } V = 7.6985341E-015$$

-----  
End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (d)

## Calculation No. 9

wall W1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcwrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = l_b = 300.00$   
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,  $M_a = -8.3458925E-011$   
Shear Force,  $V_a = -6.3856629E-015$   
EDGE -B-  
Bending Moment,  $M_b = 6.1924294E-011$   
Shear Force,  $V_b = 6.3856629E-015$   
BOTH EDGES  
Axial Force,  $F = -29388.501$   
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  $V_R = V_n = 265728.266$   
From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_n < 0.83 \cdot f_c^{0.5} \cdot h \cdot d = 312621.489$

-----  
NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw + f<sup>\*</sup>Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 124725.901$   
 $\mu_u / \mu_u - l_w / 2 = 12944.735 > 0$   
= 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 3000.00$   
 $d = 200.00$   
 $l_w = 250.00$   
 $\mu_u = 8.3458925E-011$   
 $V_u = 6.3856629E-015$   
 $N_u = 29388.501$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$   
 $V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$

Vs2 has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.50$$

Vs3 = 0.00 is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 400.00$$

Vs3 has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.00$$

$$V_f \text{ ((11-3)-(11.4), ACI 440) } = 109599.773$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

$w_f/s_f = 1$  (FRP strips adjacent to one another).

In (11.3)  $\sin \theta + \cos \theta$  is replaced with  $(\cot \theta + \cot \alpha) \sin \alpha$  which is more a generalised expression, where  $\theta$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta, \alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

$$\text{orientation 1: } \theta_1 = \theta_1 + 90^\circ = 90.00$$

$$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|), \text{ with:}$$

$$\text{total thickness per orientation, } t_{f1} = N_L * t / N_{oDir} = 1.016$$

$$d_{fv} = d \text{ (figure 11.2, ACI 440) } = 208.00$$

$$f_{fe} \text{ ((11-5), ACI 440) } = 259.312$$

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 3000.00$$

-----  
End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)  
-----

## Calculation No. 10

wall W1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####  
 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 = 1.00406  
 Element Length,  $L = 3000.00$

Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Lap Length  $l_o = 300.00$   
 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,  $V_a = 6.3108872E-029$   
 EDGE -B-  
 Shear Force,  $V_b = -6.3108872E-029$

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,  $V_e/V_r = 1.01783$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.0413E+009$

$Mu_{1+} = 2.8453E+009$ , 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

$Mu_{1-} = 3.0413E+009$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.0413E+009$

$Mu_{2+} = 2.8453E+009$ , 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

$Mu_{2-} = 3.0413E+009$ , 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  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.2735554E-006$

$M_u = 2.8453E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00232618$

$N = 27514.027$

$f_c = 16.00$

$\alpha_{co}$  (5A.5, TBDY) = 0.002

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)

From (5.4b), TBDY:  $\phi_u = 0.0035$

$\phi_{we}$  ((5.4c), TBDY) =  $\alpha_{se} * \phi_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi = \alpha_f * \phi_{pf} * f_{fe} / f_{ce}$  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,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_f = 0.015$   
 $a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web}) / A_{sec} = 0.00$   
 $a_{se1} = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $a_{se2} = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$   
 $a_{se3} = 0$  (grid does not provide confinement)  
 $p_{sh,min} = \min(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x}$  (column 1) =  $(A_{s1} \cdot h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $A_{s1} = A_{stir1} \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x}$  (column 2) =  $(A_{s2} \cdot h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $A_{s2} = A_{stir2} \cdot ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x}$  (web) =  $(A_{s3} \cdot h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $A_{s3} = A_{stir3} \cdot ns_3 = 0.00$   
 No stirrups,  $ns_3 = 2.00$

$p_{sh,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y}$  (column 1) =  $(A_{s1} \cdot h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $A_{s1} = A_{stir1} \cdot ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y}$  (column 2) =  $(A_{s2} \cdot h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $A_{s2} = A_{stir2} \cdot ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y}$  (web) =  $(A_{s3} \cdot h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $A_{s3} = A_{stir3} \cdot ns_3 = 157.0796$   
 No stirrups,  $ns_3 = 0.00$

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$

$f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c =$  confinement factor = 1.00406

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $l_o / l_{ou,min} = l_b / l_d = 0.31638566$

$$su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_1\_nominal = 0.08066667$ ,

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  $fs_1 = fs = 290.1959$

with  $Es_1 = Es = 200000.00$

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$su_2 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{min} = 0.31638566$$

$$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_2\_nominal = 0.08066667$ ,

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  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.31638566$$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.07029503$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.07029503$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.09344146$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.09344146$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

Calculation of ratio  $lb/ld$

$$\text{Lap Length: } lb/ld = 0.31638566$$

$$lb = 300.00$$

Id = 948.2098

Calculation of  $I_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

db = 16.85714

Mean strength value of all re-bars:  $f_y = 500.00$

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.24399

n = 28.00

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 2.2880917E-006$

$M_u = 3.0413E+009$

with full section properties:

b = 250.00

d = 2957.00

d' = 43.00

v = 0.00232618

N = 27514.027

$f_c = 16.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.0035$

$\mu_{we}$  ((5.4c), TBDY) =  $\alpha \cdot \text{sh}_{min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \alpha * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$\alpha_f = 0.00$

b = 250.00

h = 3000.00

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.008128$

bw = 250.00

effective stress from (A.35),  $f_{fe} = 636.1644$

$f_y = 0.00$

$\alpha_f = 0.00$

b = 3000.00

h = 250.00

From EC8 A4.4.3(6),  $p_f = 2t_f/bw = 0.00067733$

bw = 3000.00

effective stress from (A.35),  $f_{fe} = 944.3987$

R = 40.00

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}$  ((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 = 150.00

bo\_1 = 190.00

ho\_1 = 540.00

bi2\_1 = 655400.00

$\alpha_{se2} = 0.00$

sh\_2 = 150.00

bo\_2 = 190.00

ho\_2 = 540.00

$$bi2\_2 = 655400.00$$

ase3 = 0 (grid does not provide confinement)

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$$

$$ps1,x \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00083776$$

$$h1 = 600.00$$

$$As1 = Astir1 \cdot ns1 = 157.0796$$

No stirrups, ns1 = 2.00

$$ps2,x \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00083776$$

$$h2 = 600.00$$

$$As2 = Astir2 \cdot ns2 = 157.0796$$

No stirrups, ns2 = 2.00

$$ps3,x \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00188496$$

$$h3 = 1800.00$$

$$As3 = Astir3 \cdot ns3 = 0.00$$

No stirrups, ns3 = 2.00

$$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$$

$$ps1,y \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00034907$$

$$h1 = 250.00$$

$$As1 = Astir1 \cdot ns1 = 157.0796$$

No stirrups, ns1 = 2.00

$$ps2,y \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

$$As2 = Astir2 \cdot ns2 = 157.0796$$

No stirrups, ns2 = 2.00

$$ps3,y \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00$$

$$h3 = 250.00$$

$$As3 = Astir3 \cdot ns3 = 157.0796$$

No stirrups, ns3 = 0.00

$$Asec = 750000.00$$

$$s\_1 = 150.00$$

$$s\_2 = 150.00$$

$$s\_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 0.31638566$$

$$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

$$y2 = 0.00120915$$

$$sh2 = 0.00467215$$

$$ft2 = 348.235$$

$$fy2 = 290.1959$$

$$su2 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.31638566$$

$$su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08066667$ ,

For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.31638566$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08066667$ ,

considering characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = fs = 290.1959$

with  $Es_v = Es = 200000.00$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.07029503$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.07029503$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.01510726$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.09344146$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.09344146$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.02008172$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.14318411$$

$$\mu_u = MR_c (4.14) = 3.0413E+009$$

$$u = su (4.1) = 2.2880917E-006$$

-----  
Calculation of ratio  $lb/ld$

-----  
Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2735554E-006$$

$$\mu = 2.8453E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$\alpha (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0035$$

$$\phi_{we} \text{ ((5.4c), TBDY) } = \alpha s_e * \text{sh}_{, \text{min}} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$$

where  $\phi_x = \alpha f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_x = 0.00$$

$$\alpha f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$\phi_y = 0.00$$

$$\alpha f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha s_e \text{ ((5.4d), TBDY) } = (\alpha s_{e1} * A_{col1} + \alpha s_{e2} * A_{col2} + \alpha s_{e3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha s_{e1} = 0.00$$

$$sh_{,1} = 150.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$\alpha s_{e2} = 0.00$$

$$sh_{,2} = 150.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

$$\alpha s_{e3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh, \text{min}} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $p_{sh, \text{min}}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1) } = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2) } = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web) } = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00188496$$

h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00

fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07029503$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07029503$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

c = confinement factor = 1.00406

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09344146$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09344146$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 2.24399$$

$$n = 28.00$$

Calculation of  $Mu2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2880917E-006$$

$$Mu = 3.0413E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$fc = 16.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0035$

$w_e$  ((5.4c), TBDY) =  $a_{se} * sh_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = a_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 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) =  $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$a_{se2} = 0.00$

$sh_{,2} = 150.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

$a_{se3} = 0$  (grid does not provide confinement)

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,x}$  (web) =  $(A_{s3} * h_3 / s_3) / A_c = 0.00188496$

$h_3 = 1800.00$

$A_{s3} = A_{stir3} * n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (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, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07029503

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07029503

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01510726

and confined core properties:

b = 190.00

d = 2927.00

d' = 13.00

fcc (5A.2, TBDY) = 16.06499

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = \text{Asl,ten}/(b*d)*(fs1/fc) = 0.09344146$$

$$2 = \text{Asl,com}/(b*d)*(fs2/fc) = 0.09344146$$

$$v = \text{Asl,mid}/(b*d)*(fsv/fc) = 0.02008172$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.14318411$$

$$Mu = MRc (4.14) = 3.0413E+009$$

$$u = su (4.1) = 2.2880917E-006$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Lap Length:  $l_b/l_d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \text{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.9920E+006$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r1} = V_n < 0.83*fc'^{0.5}*h*d$

-----  
NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$

$$Mu/V_u - l_w/2 = 0.00 <= 0$$

= 1 (normal-weight concrete)

$$fc' = 16.00, \text{ but } fc'^{0.5} <= 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$Mu = 2.8012401E-010$$

$$V_u = 6.3108872E-029$$

$$Nu = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

$V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

$V_{s2}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

Vs3 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 1.5581E+006$$

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|), \text{ with:}$$

total thickness per orientation,  $t_{f1} = NL * t / \text{NoDir} = 1.016$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 2957.00$$

$$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$$

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

with  $f_u = 0.01$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 250.00$$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920E+006$

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) 'Vw' is replaced by 'Vw + f \* V\_f'  
where V\_f is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$

$$\mu_u / \nu_u - l_w / 2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$f_c' = 16.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$\mu_u = 2.8012401E-010$$

$$\nu_u = 6.3108872E-029$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

Vs1 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

Vs2 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

Vs3 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 1.5581E+006$$

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|), \text{ with:}$$

total thickness per orientation,  $t_{f1} = NL * t / \text{NoDir} = 1.016$

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 <= 1.5943E+006  
bw = 250.00

-----  
End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1  
At local axis: 3  
-----

Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcrcws

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.85$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$

#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####  
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 = 1.00406  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
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,  $V_a = 0.00$   
EDGE -B-  
Shear Force,  $V_b = 0.00$   
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:  $As_{,ten} = 2368.761$

-Compression:  $As_{,com} = 2368.761$

-Middle:  $As_{,mid} = 0.00$

(According to 10.7.2.3  $As_{,mid}$  is setted equal to zero)

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.14054053$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7738E+008$

$Mu_{1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7738E+008$

$Mu_{2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 3.4223799E-005$

$M_u = 1.4516E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

$\phi_{co}$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.0035$

$\phi_{we}$  ((5.4c), TBDY) =  $ase * \phi_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi_f = af * pf * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.00$

$af = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35),  $f_{f,e} = 636.1644$

$\phi_y = 0.00$

$af = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $pf = 2tf/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35),  $f_{f,e} = 944.3987$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 * A_{col1} + ase_2 * A_{col2} + ase_3 * A_{web}) / A_{sec} = 0.00$   
 $ase_1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $ase_2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$   
 $ase_3 = 0$  (grid does not provide confinement)  
 $psh_{,min} = \text{Min}(psh_{,x}, psh_{,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $psh_{,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $As_3 = Astir_3 * ns_3 = 0.00$   
 No stirrups,  $ns_3 = 2.00$

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $As_3 = Astir_3 * ns_3 = 157.0796$   
 No stirrups,  $ns_3 = 0.00$

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $l_o / l_{ou,min} = l_b / l_d = 0.31638566$   
 $su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.03226667$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08066667$ ,

For 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  $fs1 = fs = 290.1959$

with  $Es1 = Es = 200000.00$

$y2 = 0.00120915$

$sh2 = 0.00467215$

$ft2 = 348.235$

$fy2 = 290.1959$

$su2 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 0.31638566$

$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08066667$ ,

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  $fs2 = fs = 290.1959$

with  $Es2 = Es = 200000.00$

$yv = 0.00120915$

$shv = 0.00467215$

$ftv = 348.235$

$fyv = 290.1959$

$suv = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.31638566$

$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.06885062$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.06885062$

$v = Asl, mid / (b * d) * (fsv / fc) = 0.00$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$fcc (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c = confinement\ factor = 1.00406$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.08209659$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.08209659$

$v = Asl, mid / (b * d) * (fsv / fc) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < vs, y2$  - LHS eq.(4.5) is satisfied

---

$su (4.9) = 0.18563201$

$Mu = MRc (4.14) = 1.4516E+008$

$u = su (4.1) = 3.4223799E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $I_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$d_b = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 3.5153739E-005$

$\mu = 1.7738E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.0035$

$\mu_{cc}$  ((5.4c), TBDY) =  $\alpha * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \alpha * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35),  $f_{fe} = 636.1644$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $f_{fe} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_{,2} = 150.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

ase3 = 0 (grid does not provide confinement)  
psh,min = Min(psh,x , psh,y) = 0.00069813  
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
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 = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00  
From ((5.A5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406  
y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_d = 0.31638566  
su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667  
From table 5A.1, TBDY: esu1\_nominal = 0.08066667,  
For 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 = 290.1959  
with Es1 = Es = 200000.00  
y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_b,min = 0.31638566  
su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $es_{u2\_nominal} = 0.08066667$ ,

For calculation of  $es_{u2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$

$sh_v = 0.00467215$

$ft_v = 348.235$

$fy_v = 290.1959$

$s_{uv} = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.31638566$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $es_{uv\_nominal} = 0.08066667$ ,

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_v = fs = 290.1959$

with  $Es_v = Es = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.06885062$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.06885062$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.04675268$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$f_{cc} (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c = \text{confinement factor} = 1.00406$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.08209659$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.08209659$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.20717489$

$\mu_u = MR_c (4.14) = 1.7738E+008$

$u = s_u (4.1) = 3.5153739E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$db = 16.85714$

Mean strength value of all re-bars:  $fy = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

-----  
Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$\alpha (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0035$$

$$\omega_e \text{ ((5.4c), TBDY) } = \alpha s_e * \text{sh}_{, \text{min}} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$$

where  $\phi = \alpha f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_x = 0.00$$

$$\alpha f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$\phi_y = 0.00$$

$$\alpha f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha s_e \text{ ((5.4d), TBDY) } = (\alpha s_{e1} * A_{col1} + \alpha s_{e2} * A_{col2} + \alpha s_{e3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha s_{e1} = 0.00$$

$$\text{sh}_{,1} = 150.00$$

$$\text{bo}_{,1} = 190.00$$

$$\text{ho}_{,1} = 540.00$$

$$\text{bi}_{2,1} = 655400.00$$

$$\alpha s_{e2} = 0.00$$

$$\text{sh}_{,2} = 150.00$$

$$\text{bo}_{,2} = 190.00$$

$$\text{ho}_{,2} = 540.00$$

$$\text{bi}_{2,2} = 655400.00$$

$$\alpha s_{e3} = 0 \text{ (grid does not provide confinement)}$$

$$\text{psh}_{, \text{min}} = \text{Min}(\text{psh}_{,x}, \text{psh}_{,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $\text{psh}_{, \text{min}}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\text{psh}_{,x} = \text{ps}_{1,x} + \text{ps}_{2,x} + \text{ps}_{3,x} = 0.00356047$$

$$\text{ps}_{1,x} \text{ (column 1) } = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{\text{stir1}} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$\text{ps}_{2,x} \text{ (column 2) } = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{\text{stir2}} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$\text{ps}_{3,x} \text{ (web) } = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{sv} = f_s = 290.1959$   
with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06885062$   
 $2 = A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06885062$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

and confined core properties:

$b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.08209659$   
 $2 = A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08209659$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->  
 $su (4.9) = 0.18563201$   
 $Mu = MRc (4.14) = 1.4516E+008$   
 $u = su (4.1) = 3.4223799E-005$

-----  
Calculation of ratio  $lb/ld$

-----  
Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$   
 $ld = 948.2098$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$

$db = 16.85714$   
Mean strength value of all re-bars:  $f_y = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.24399$   
 $n = 28.00$

-----  
Calculation of  $Mu_2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 3.5153739E-005$   
 $Mu = 1.7738E+008$

-----  
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:  $cu = 0.0035$

$w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe} / f_{ce} + \text{Min}( f_x, f_y ) = 0.00$   
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,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$   
 $a_{se1} = 0.00$   
 $sh_{,1} = 150.00$   
 $bo_{,1} = 190.00$   
 $ho_{,1} = 540.00$   
 $bi_{2,1} = 655400.00$   
 $a_{se2} = 0.00$   
 $sh_{,2} = 150.00$   
 $bo_{,2} = 190.00$   
 $ho_{,2} = 540.00$   
 $bi_{2,2} = 655400.00$   
 $a_{se3} = 0$  (grid does not provide confinement)  
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x}$  (column 1) =  $(A_{s1} * h_1 / s_{,1}) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $A_{s1} = A_{stir1} * ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x}$  (column 2) =  $(A_{s2} * h_2 / s_{,2}) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $A_{s2} = A_{stir2} * ns_2 = 157.0796$   
No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x}$  (web) =  $(A_{s3} * h_3 / s_{,3}) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $A_{s3} = A_{stir3} * ns_3 = 0.00$   
No stirrups,  $ns_3 = 2.00$

$p_{sh,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y}$  (column 1) =  $(A_{s1} * h_1 / s_{,1}) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $A_{s1} = A_{stir1} * ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y}$  (column 2) =  $(A_{s2} * h_2 / s_{,2}) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $A_{s2} = A_{stir2} * ns_2 = 157.0796$   
No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y}$  (web) =  $(A_{s3} * h_3 / s_{,3}) / A_c = 0.00$   
 $h_3 = 250.00$   
 $A_{s3} = A_{stir3} * ns_3 = 157.0796$   
No stirrups,  $ns_3 = 0.00$

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 =  $Asl,ten/(b*d)*(fs1/fc) = 0.08209659$

2 =  $Asl,com/(b*d)*(fs2/fc) = 0.08209659$

v =  $Asl,mid/(b*d)*(fsv/fc) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

v < vs,y2 - LHS eq.(4.5) is satisfied

---

su (4.9) = 0.20717489

Mu = MRc (4.14) = 1.7738E+008

u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Lap Length: lb/l<sub>d</sub> = 0.31638566

lb = 300.00

l<sub>d</sub> = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 2.24399

n = 28.00

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 841398.394

-----  
Calculation of Shear Strength at edge 1, Vr1 = 841398.394

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 = 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 = 1.9099438E-011

Vu = 0.00

Nu = 27514.027

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 + Vs3 = 83775.804

Vs1 = 41887.902 is calculated for pseudo-Column 1, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs1 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs2 = 41887.902 is calculated for pseudo-Column 2, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs2 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs3 = 0.00 is calculated for web, with:

$d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$   
 $V_{s3}$  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).  
 $\ln(11.3) \sin \theta + \cos \theta$  is replaced with  $(\cot \theta + \cot \alpha) \sin \alpha$  which is more a generalised expression,  
 where  $\theta$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(\theta, \alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.016$   
 $d_{fv} = d$  (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,  $V_{r2} = 841398.394$   
 From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r2} = V_n < 0.83 * f_c'^{0.5} * h * d$

NOTE: In expression (22.5.1.1) ' $V_w$ ' is replaced by ' $V_w + f^*V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$   
 $\mu_u / V_u - l_w / 2 = 0.00 \leq 0$   
 $= 1$  (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 3000.00$   
 $d = 200.00$   
 $l_w = 250.00$   
 $\mu_u = 1.9099438E-011$   
 $V_u = 0.00$   
 $N_u = 27514.027$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$   
 $V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s3} = 0.00$  is calculated for web, with:  
 $d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$

$V_{s3}$  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).  
 $\ln(11.3) \sin \theta + \cos \theta$  is replaced with  $(\cot \theta + \cot \alpha) \sin \alpha$  which is more a generalised expression,  
 where  $\theta$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $\theta_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.016$

$d_{fv} = d$  (figure 11.2, ACI 440) = 208.00

$f_{fe}$  ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.01$

From (11-11), ACI 440:  $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

-----  
End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcrws

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.85$

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

$\rho_n = 0.00069813$

-----  
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  $\rho_{s1} = A_{s1} * b_1 / s_1 = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$s_1 = 150.00$

total area of hoops perpendicular to shear axis,  $A_{s1} = 157.0796$

(pseudo-col.2  $\rho_{s2} = A_{s2} * b_2 / s_2 = (A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$s_2 = 150.00$

total area of hoops perpendicular to shear axis,  $A_{s2} = 157.0796$

(grid  $\rho_{s3} = A_{s3} * b_3 / s_3 = (A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$s_3 = 200.00$

total area of hoops perpendicular to shear axis,  $A_{s3} = 0.00$

total section area,  $A_c = 750000.00$

-----  
Consequently:

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at  $135^\circ$ )

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

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  
-----

Axial Force,  $F = -29388.501$   
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,  $Db_L = 17.33333$

-----  
-----  
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  $u_{R} = * u = 0.02$   
from table 10-20:  $u = 0.02352941$   
with:

- Condition i (shear wall and wall segments)  
-  $(As - As') * f_y + P) / (t_w * l_w * f_c') = -0.20908486$   
 $As = 0.00$   
 $As' = 6346.017$   
 $f_y = 400.00$   
 $P = 29388.501$   
 $t_w = 250.00$   
 $l_w = 3000.00$   
 $f_c = 16.00$

-----  
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: Collapse Prevention (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,  $\gamma = 0.85$

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

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,  $M_a = 8.5315E+007$

Shear Force,  $V_a = -28549.607$

### EDGE -B-

Bending Moment,  $M_b = 348518.893$

Shear Force,  $V_b = 28549.607$

### BOTH EDGES

Axial Force,  $F = -29388.501$

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  $V_R = V_n = 1.6932E+006$

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:  $V_c = 613244.962$

$\mu_u / \mu - l_w / 2 = 1488.32 > 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$\mu_u = 8.5315E+007$

$V_u = 28549.607$

$N_u = 29388.501$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s2}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

$d = 1440.00$

$A_v = 157079.633$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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  $\alpha$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ , as well as for 2 crack directions,  $\alpha = 45^\circ$  and  $\alpha = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\alpha = 45^\circ$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$ , with:

total thickness per orientation,  $tf1 = NL*t/NoDir = 1.016$   
 $dfv = d$  (figure 11.2, ACI 440) = 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:  $Vs + Vf \leq 1.5943E+006$   
 $bw = 250.00$

-----  
 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: Collapse Prevention (data interpolation between analysis steps 1 and 2)  
 Analysis: Uniform +X  
 Check: Chord rotation capacity (  $\theta$  )  
 Edge: Start  
 Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1  
 At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcwrs

Constant Properties

-----  
 Knowledge Factor,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####

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 = 1.00406

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = 300.00$

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,  $V_a = 6.3108872E-029$

EDGE -B-

Shear Force,  $V_b = -6.3108872E-029$

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 ,  $V_e/V_r = 1.01783$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$

with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 3.0413E+009$

$M_{u1+} = 2.8453E+009$ , 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

$M_{u1-} = 3.0413E+009$ , 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

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 3.0413E+009$

$M_{u2+} = 2.8453E+009$ , 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

$M_{u2-} = 3.0413E+009$ , 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  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2735554E-006$$

$$\mu = 2.8453E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0035$$

$$\phi_{we} \text{ ((5.4c), TBDY)} = a_{se} * \phi_{sh, \min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$$

where  $\phi = a_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$\phi_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h,1} = 150.00$$

$$b_{o,1} = 190.00$$

$$h_{o,1} = 540.00$$

$$b_{i2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h,2} = 150.00$$

$$b_{o,2} = 190.00$$

$$h_{o,2} = 540.00$$

$$b_{i2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh, \min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $p_{sh, \min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

No stirrups,  $n_{s1} = 2.00$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

No stirrups,  $n_{s2} = 2.00$

$$ps_{3,x}(\text{web}) = (As_3^3 \cdot h_3 / s_3) / Ac = 0.00188496$$

$$h_3 = 1800.00$$

$$As_3 = Astir_3 \cdot ns_3 = 0.00$$

$$\text{No stirups, } ns_3 = 2.00$$

$$psh_y = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$$

$$ps_{1,y}(\text{column 1}) = (As_1 \cdot h_1 / s_1) / Ac = 0.00034907$$

$$h_1 = 250.00$$

$$As_1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$ps_{2,y}(\text{column 2}) = (As_2 \cdot h_2 / s_2) / Ac = 0.00034907$$

$$h_2 = 250.00$$

$$As_2 = Astir_2 \cdot ns_2 = 157.0796$$

$$\text{No stirups, } ns_2 = 2.00$$

$$ps_{3,y}(\text{web}) = (As_3 \cdot h_3 / s_3) / Ac = 0.00$$

$$h_3 = 250.00$$

$$As_3 = Astir_3 \cdot ns_3 = 157.0796$$

$$\text{No stirups, } ns_3 = 0.00$$

$$A_{sec} = 750000.00$$

$$s_1 = 150.00$$

$$s_2 = 150.00$$

$$s_3 = 200.00$$

$$f_{ywe} = 500.00$$

$$f_{ce} = 16.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$y_1 = 0.00120915$$

$$sh_1 = 0.00467215$$

$$ft_1 = 348.235$$

$$fy_1 = 290.1959$$

$$su_1 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/ld = 0.31638566$$

$$su_1 = 0.4 \cdot esu_{1,nominal} ((5.5), \text{TB DY}) = 0.03226667$$

$$\text{From table 5A.1, TB DY: } esu_{1,nominal} = 0.08066667,$$

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, TB DY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 290.1959$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$su_2 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.31638566$$

$$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), \text{TB DY}) = 0.03226667$$

$$\text{From table 5A.1, TB DY: } esu_{2,nominal} = 0.08066667,$$

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, TB DY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 290.1959$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/d = 0.31638566$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.03226667$$

$$\text{From table 5A.1, TBDY: } e_{suv,nominal} = 0.08066667,$$

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $\gamma_v$ ,  $sh_v, ft_v, fy_v$ , it is considered characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$$\gamma_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } f_{sv} = f_s = 290.1959$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.07029503$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.07029503$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.09344146$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.09344146$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.13770595$$

$$M_u = MR_c (4.14) = 2.8453E+009$$

$$u = s_u (4.1) = 2.2735554E-006$$

Calculation of ratio  $l_b/d$

$$\text{Lap Length: } l_b/d = 0.31638566$$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

Calculation of  $Mu_1$ -

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2880917E-006$$

$$M_u = 3.0413E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, cc) = 0.0035$$

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),  $f_{f,e} = 636.1644$

-----  
 $f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

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) =  $(a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$

$a_{se1} = 0.00$

$s_{h_1} = 150.00$

$b_{o_1} = 190.00$

$h_{o_1} = 540.00$

$b_{i2_1} = 655400.00$

$a_{se2} = 0.00$

$s_{h_2} = 150.00$

$b_{o_2} = 190.00$

$h_{o_2} = 540.00$

$b_{i2_2} = 655400.00$

$a_{se3} = 0$  (grid does not provide confinement)

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,x}$  (web) =  $(A_{s3} * h_3 / s_3) / A_c = 0.00188496$

$h_3 = 1800.00$

$A_{s3} = A_{stir3} * n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

-----  
 $p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1} * n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2} * n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

As3 = Astir3\*ns3 = 157.0796  
No stirups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07029503

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07029503

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01510726

and confined core properties:

b = 190.00

d = 2927.00

d' = 13.00

$$f_{cc} (5A.2, \text{TBDY}) = 16.06499$$

$$c_c (5A.5, \text{TBDY}) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09344146$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09344146$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02008172$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14318411$$

$$M_u = M_{Rc} (4.14) = 3.0413E+009$$

$$u = s_u (4.1) = 2.2880917E-006$$

-----  
Calculation of ratio  $l_b/l_d$

$$\text{Lap Length: } l_b/l_d = 0.31638566$$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \text{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $M_{u2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2735554E-006$$

$$M_u = 2.8453E+009$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e ((5.4c), \text{TBDY}) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

h = 250.00  
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,  $tf = NL*t*\text{Cos}(b1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase((5.4d), \text{TBDY}) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$   
ase1 = 0.00  
sh\_1 = 150.00  
bo\_1 = 190.00  
ho\_1 = 540.00  
bi2\_1 = 655400.00  
ase2 = 0.00  
sh\_2 = 150.00  
bo\_2 = 190.00  
ho\_2 = 540.00  
bi2\_2 = 655400.00  
ase3 = 0 (grid does not provide confinement)  
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$

Expression ((5.4d), TBDY) for  $psh,min$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$   
 $ps1,x$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00083776$   
h1 = 600.00  
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups, ns1 = 2.00  
 $ps2,x$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00083776$   
h2 = 600.00  
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups, ns2 = 2.00  
 $ps3,x$  (web) =  $(As3*h3/s_3)/Ac = 0.00188496$   
h3 = 1800.00  
 $As3 = Astir3*ns3 = 0.00$   
No stirrups, ns3 = 2.00

$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$   
 $ps1,y$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00034907$   
h1 = 250.00  
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups, ns1 = 2.00  
 $ps2,y$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00034907$   
h2 = 250.00  
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups, ns2 = 2.00  
 $ps3,y$  (web) =  $(As3*h3/s_3)/Ac = 0.00$   
h3 = 250.00  
 $As3 = Astir3*ns3 = 157.0796$   
No stirrups, ns3 = 0.00

Asec = 750000.00  
s\_1 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00

$f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.31638566$$

$$s_u1 = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08066667$ ,

For calculation of  $e_{su1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 290.1959$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$s_u2 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.31638566$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $e_{su2,nominal} = 0.08066667$ ,

For calculation of  $e_{su2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = f_s = 290.1959$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$s_{uv} = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.31638566$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08066667$ ,

considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $e_{suv,nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = f_s = 290.1959$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.07029503$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.07029503$$

$$v = A_{s1,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.09344146$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.09344146$$

$$v = A_{s1,mid}/(b*d) * (f_{sv}/f_c) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.13770595$$

$$\mu_u = M_{Rc} (4.14) = 2.8453E+009$$

$$u = s_u (4.1) = 2.2735554E-006$$

Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.31638566$

$l_b = 300.00$

$l_d = 948.2098$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$= 1$

$db = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 2.2880917E-006$

$\mu = 3.0413E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00232618$

$N = 27514.027$

$f_c = 16.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu, \mu_c) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu = 0.0035$

$\mu_e$  ((5.4c), TBDY) =  $\alpha * \text{sh}_{\min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \alpha * \rho_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $\rho_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35),  $f_{fe} = 636.1644$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $\rho_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35),  $f_{fe} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_1 = 150.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi_{2,1} = 655400.00$

ase2 = 0.00  
sh\_2 = 150.00  
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) = 0.00069813

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
h2 = 600.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,x (web) = (As3\*h3/s\_3)/Ac = 0.00188496  
h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirrups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
h2 = 250.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,y (web) = (As3\*h3/s\_3)/Ac = 0.00  
h3 = 250.00  
As3 = Astir3\*ns3 = 157.0796  
No stirrups, ns3 = 0.00

Asec = 750000.00  
s\_1 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 0.31638566$

$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08066667$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$

$sh_v = 0.00467215$

$ft_v = 348.235$

$fy_v = 290.1959$

$su_v = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.31638566$

$su_v = 0.4 * esu_{v,nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $esu_{v,nominal} = 0.08066667$ ,

considering characteristic value  $fsy_v = fsv/1.2$ , 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  $fsy_v = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = fs = 290.1959$

with  $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.07029503$

$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.07029503$

$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.01510726$

and confined core properties:

$b = 190.00$

$d = 2927.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c =$  confinement factor  $= 1.00406$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09344146$

$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09344146$

$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.02008172$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14318411$

$Mu = MRc (4.14) = 3.0413E+009$

$u = su (4.1) = 2.2880917E-006$

-----  
Calculation of ratio  $l_b/l_d$   
-----

Lap Length:  $l_b/l_d = 0.31638566$

$l_b = 300.00$

$l_d = 948.2098$

Calculation of  $l_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$= 1$

$db = 16.85714$

Mean strength value of all re-bars:  $fy = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$   
-----

-----  
-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.9920\text{E}+006$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920\text{E}+006$   
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:  $V_c = 653502.805$   
 $\mu_u / \mu_u - l_w / 2 = 0.00 \leq 0$   
= 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 250.00$   
 $d = 2400.00$   
 $l_w = 3000.00$   
 $\mu_u = 2.8012401\text{E}-010$   
 $V_u = 6.3108872\text{E}-029$   
 $N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$

$V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$d = 480.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$

$V_{s2}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

$d = 1440.00$   
 $A_v = 157079.633$   
 $s = 200.00$   
 $f_y = 400.00$

$V_{s3}$  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)  $\sin \theta + \cos \theta$  is replaced with  $(\cot \theta + \cot \alpha) \sin \alpha$  which is more a generalised expression,  
where  $\theta$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta, \alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ ,  
as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$  (figure 11.2, ACI 440) =  $2957.00$

$f_{fe}$  ((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:  $V_s + V_f \leq 1.5943\text{E}+006$

$b_w = 250.00$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920\text{E}+006$

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:  $V_c = 653502.805$   
 $\mu_u / \mu_u - l_w / 2 = 0.00 \leq 0$   
= 1 (normal-weight concrete)

fc' = 16.00, but  $fc^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

h = 250.00

d = 2400.00

lw = 3000.00

Mu = 2.8012401E-010

Vu = 6.3108872E-029

Nu = 27514.027

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

d = 480.00

$A_v = 157079.633$

s = 150.00

$f_y = 400.00$

$V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

d = 480.00

$A_v = 157079.633$

s = 150.00

$f_y = 400.00$

$V_{s2}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

d = 1440.00

$A_v = 157079.633$

s = 200.00

$f_y = 400.00$

$V_{s3}$  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:  $\theta = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|)$ , with:

total thickness per orientation,  $t_{f1} = NL \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$  (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:  $V_s + V_f \leq 1.5943E+006$

$b_w = 250.00$

-----  
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,  $\gamma = 0.85$

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

```

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$ 
#####
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 = 1.00406
Element Length,  $L = 3000.00$ 
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length  $l_o = 300.00$ 
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,  $V_a = 0.00$ 
EDGE -B-
Shear Force,  $V_b = 0.00$ 
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 ,  $V_e/V_r = 0.14054053$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$ 
with
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.7738E+008$ 
 $\mu_{u1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 1.7738E+008$ 
 $\mu_{u2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

-----
Calculation of  $\mu_{u1+}$ 
-----

```

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0035$$

$$\phi_{we} \text{ ((5.4c), TBDY)} = a_{se} * \phi_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_{fx}, \phi_{fy}) = 0.00$$

where  $\phi_f = a_f * \phi_{f'f} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$\phi_{fy} = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$sh_1 = 150.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$a_{se2} = 0.00$$

$$sh_2 = 150.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $\phi_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{sh,x} = \phi_{ps1,x} + \phi_{ps2,x} + \phi_{ps3,x} = 0.00356047$$

$$\phi_{ps1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$\phi_{ps2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$\phi_{ps3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_b,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_d = 0.31638566

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.06885062$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.06885062$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

and confined core properties:

$$b = 2940.00$$

$$d = 178.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$c$  = confinement factor = 1.00406

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.08209659$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.08209659$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < vs,y2$  - LHS eq.(4.5) is satisfied

---

$$su (4.9) = 0.18563201$$

$$Mu = MRc (4.14) = 1.4516E+008$$

$$u = su (4.1) = 3.4223799E-005$$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 2.24399$$

$$n = 28.00$$

Calculation of  $Mu1$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.5153739E-005$$

$$Mu = 1.7738E+008$$

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  $\text{Shear\_factor}$  is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0035$

$w_e$  ((5.4c), TBDY) =  $a_{se} \cdot s_{h,min} \cdot f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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)

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35),  $f_{f,e} = 636.1644$

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35),  $f_{f,e} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL \cdot t \cdot \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web})/A_{sec} = 0.00$

$a_{se1} = 0.00$

$s_{h,1} = 150.00$

$b_{o,1} = 190.00$

$h_{o,1} = 540.00$

$b_{i2,1} = 655400.00$

$a_{se2} = 0.00$

$s_{h,2} = 150.00$

$b_{o,2} = 190.00$

$h_{o,2} = 540.00$

$b_{i2,2} = 655400.00$

$a_{se3} = 0$  (grid does not provide confinement)

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,x}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00188496$

$h_3 = 1800.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$

No stirups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.08209659$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08209659$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05574729$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.20717489$$

$$Mu = MRc (4.14) = 1.7738E+008$$

$$u = su (4.1) = 3.5153739E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Lap Length:  $l_b/l_d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $Mu_{2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

-----  
with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.0035$$

$$w_e ((5.4c), TBDY) = ase * sh, \min * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where  $f = af * pf * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$af = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } pf = 2t_f / bw = 0.008128$$

$$bw = 250.00$$

$$\text{effective stress from (A.35), } ff_e = 636.1644$$

$$f_y = 0.00$$

$$af = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

From EC8 A4.4.3(6),  $pf = 2tf/bw = 0.00067733$   
 $bw = 3000.00$   
effective stress from (A.35),  $ff,e = 944.3987$

-----  
 $R = 40.00$   
Effective FRP thickness,  $tf = NL*t*Cos(b1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase((5.4d), TBDY) = (ase1*Acol1 + ase2*Acol2 + ase3*Aweb)/Asec = 0.00$   
 $ase1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi2_1 = 655400.00$   
 $ase2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi2_2 = 655400.00$   
 $ase3 = 0$  (grid does not provide confinement)  
 $psh,min = Min(psh,x, psh,y) = 0.00069813$

Expression ((5.4d), TBDY) for  $psh,min$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$   
 $ps1,x$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00083776$   
 $h1 = 600.00$   
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups,  $ns1 = 2.00$   
 $ps2,x$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00083776$   
 $h2 = 600.00$   
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups,  $ns2 = 2.00$   
 $ps3,x$  (web) =  $(As3*h3/s_3)/Ac = 0.00188496$   
 $h3 = 1800.00$   
 $As3 = Astir3*ns3 = 0.00$   
No stirrups,  $ns3 = 2.00$

-----  
 $psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$   
 $ps1,y$  (column 1) =  $(As1*h1/s_1)/Ac = 0.00034907$   
 $h1 = 250.00$   
 $As1 = Astir1*ns1 = 157.0796$   
No stirrups,  $ns1 = 2.00$   
 $ps2,y$  (column 2) =  $(As2*h2/s_2)/Ac = 0.00034907$   
 $h2 = 250.00$   
 $As2 = Astir2*ns2 = 157.0796$   
No stirrups,  $ns2 = 2.00$   
 $ps3,y$  (web) =  $(As3*h3/s_3)/Ac = 0.00$   
 $h3 = 250.00$   
 $As3 = Astir3*ns3 = 157.0796$   
No stirrups,  $ns3 = 0.00$

-----  
 $Asec = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $fywe = 500.00$   
 $fce = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c =$  confinement factor = 1.00406

$y1 = 0.00120915$   
 $sh1 = 0.00467215$   
 $ft1 = 348.235$   
 $fy1 = 290.1959$   
 $su1 = 0.00579712$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

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) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.08209659

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08209659

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) = 0.18563201

Mu = MRc (4.14) = 1.4516E+008

u = su (4.1) = 3.4223799E-005

-----  
Calculation of ratio lb/d

Lap Length:  $l_b/l_d = 0.31638566$

$l_b = 300.00$

$l_d = 948.2098$

Calculation of  $l_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$= 1$

$db = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_2$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 3.5153739E-005$

$\mu_2 = 1.7738E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu_c$ :  $\mu_c^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.0035$

$\mu_{we}$  ((5.4c), TBDY) =  $\alpha s_e * \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \alpha f * p_f * f_{fe} / f_{ce}$  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),  $f_{f,e} = 636.1644$

$f_y = 0.00$

$\alpha f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $f_{f,e} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha s_e$  ((5.4d), TBDY) =  $(\alpha s_{e1} * A_{col1} + \alpha s_{e2} * A_{col2} + \alpha s_{e3} * A_{web}) / A_{sec} = 0.00$

$\alpha s_{e1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$\alpha s_{e2} = 0.00$

sh\_2 = 150.00  
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) = 0.00069813

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x = ps1,x+ps2,x+ps3,x = 0.00356047

ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776

h1 = 600.00

As1 = Astir1\*ns1 = 157.0796

No stirrups, ns1 = 2.00

ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776

h2 = 600.00

As2 = Astir2\*ns2 = 157.0796

No stirrups, ns2 = 2.00

ps3,x (web) = (As3\*h3/s\_3)/Ac = 0.00188496

h3 = 1800.00

As3 = Astir3\*ns3 = 0.00

No stirrups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.00069813

ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907

h1 = 250.00

As1 = Astir1\*ns1 = 157.0796

No stirrups, ns1 = 2.00

ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907

h2 = 250.00

As2 = Astir2\*ns2 = 157.0796

No stirrups, ns2 = 2.00

ps3,y (web) = (As3\*h3/s\_3)/Ac = 0.00

h3 = 250.00

As3 = Astir3\*ns3 = 157.0796

No stirrups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348,235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.08209659

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08209659

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05574729

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.20717489

Mu = MRc (4.14) = 1.7738E+008

u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/ld

-----  
Lap Length: lb/ld = 0.31638566

lb = 300.00

ld = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.24399

n = 28.00

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 841398.394$

Calculation of Shear Strength at edge 1,  $V_{r1} = 841398.394$   
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)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 1.9099438E-011$

$V_u = 0.00$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

$V_{s3} = 0.00$  is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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)  $\sin \alpha + \cos \alpha$  is replaced with  $(\cot \alpha + \cot \alpha) \sin \alpha$  which is more a generalised expression,  
where  $\alpha$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\alpha)$ , is implemented for every different fiber orientation  $\alpha_i$ ,  
as well as for 2 crack directions,  $\alpha = 45^\circ$  and  $\alpha = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\alpha = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha)|, |V_f(-45, \alpha)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$  (figure 11.2, ACI 440) = 208.00

$f_{fe}$  ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.01$

From (11-11), ACI 440:  $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 841398.394$

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:  $V_c = 653502.805$

$$\mu_u/V_u - l_w/2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$f_c' = 16.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 3000.00$$

$$d = 200.00$$

$$l_w = 250.00$$

$$\mu_u = 1.9099438E-011$$

$$V_u = 0.00$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

$V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.50$$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

$V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.50$$

$V_{s3} = 0.00$  is calculated for web, with:

$$d = 200.00$$

$$A_v = 0.00$$

$$s = 200.00$$

$$f_y = 400.00$$

$V_{s3}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.00$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 109599.773$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

$w_f/s_f = 1$  (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.

$$\text{orientation 1: } \theta = b1 + 90^\circ = 90.00$$

$$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|), \text{ with:}$$

$$\text{total thickness per orientation, } t_{f1} = N_L * t / \text{NoDir} = 1.016$$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 208.00$$

$$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$$

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 3000.00$$

-----  
End Of Calculation of Shear Capacity 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,  $\gamma = 0.85$

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

$$\rho_n = 0.00069813$$

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  $ps_1 = As_1 * b_1 / s_1 = (As_1 * h_1 / s_1) / Ac = 0.00034907$

$h_1 = 250.00$

$s_1 = 150.00$

total area of hoops perpendicular to shear axis,  $As_1 = 157.0796$

(pseudo-col.2  $ps_2 = As_2 * b_2 / s_2 = (As_2 * h_2 / s_2) / Ac = 0.00034907$

$h_2 = 250.00$

$s_2 = 150.00$

total area of hoops perpendicular to shear axis,  $As_2 = 157.0796$

(grid  $ps_3 = As_3 * b_3 / s_3 = (As_3 * h_3 / s_3) / Ac = 0.00$

$h_3 = 250.00$

$s_3 = 200.00$

total area of hoops perpendicular to shear axis,  $As_3 = 0.00$

total section area,  $Ac = 750000.00$

Consequently:

Existing material of Secondary Member: Concrete Strength,  $fc = fc\_lower\_bound = 16.00$

Existing material of Secondary Member: Steel Strength,  $fs = fs\_lower\_bound = 400.00$

Concrete Elasticity,  $Ec = 21019.039$

Steel Elasticity,  $Es = 200000.00$

Total Height,  $H_{tot} = 3000.00$

Edges Width,  $Wedg = 250.00$

Edges Height,  $Hedg = 600.00$

Web Width,  $W_{web} = 250.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness,  $t = 1.016$

Tensile Strength,  $ff_u = 1055.00$

Tensile Modulus,  $E_f = 64828.00$

Elongation,  $ef_u = 0.01$

Number of directions,  $NoDir = 1$

Fiber orientations,  $bi = 0.00^\circ$

Number of layers,  $NL = 1$

Radius of rounding corners,  $R = 40.00$

Stepwise Properties

Bending Moment,  $M = -8.3458925E-011$

Shear Force,  $V_2 = -6.3856629E-015$

Shear Force,  $V_3 = -28549.607$

Axial Force,  $F = -29388.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_{lt} = 0.00$

-Compression:  $As_{lc} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{l,ten} = 2368.761$

-Compression:  $As_{l,com} = 2368.761$

-Middle:  $As_{l,mid} = 1608.495$

Mean Diameter of Tension Reinforcement,  $DbL = 17.20$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = * u = 0.01382101$

$u = y + p = 0.01626001$

- Calculation of  $y$  -

$$y = (M_y \cdot I_p) / (E I)_{\text{Eff}} = 0.00126001 \text{ ((10-5), ASCE 41-17)}$$

$$M_y = 1.5087E+008$$

$$(E I)_{\text{Eff}} = 0.35 \cdot E_c \cdot I \text{ (table 10-5)}$$

$$E_c \cdot I = 8.2106E+013$$

$$I_p = 0.5 \cdot d = 0.5 \cdot (0.8 \cdot h) = 240.00$$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 8.7651352E-006$$

$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b / I_d)^{2/3}) = 269.394$$

$$d = 208.00$$

$$y = 0.26118462$$

$$A = 0.01034472$$

$$B = 0.00628654$$

$$\text{with } p_t = 0.00379609$$

$$p_c = 0.00379609$$

$$p_v = 0.00257772$$

$$N = 29388.501$$

$$b = 3000.00$$

$$\lambda = 0.20192308$$

$$y_{\text{comp}} = 2.54444482E-005$$

$$\text{with } f_c^* \text{ (12.3, (ACI 440))} = 16.002$$

$$f_c = 16.00$$

$$f_l = 0.17503396$$

$$b = 3000.00$$

$$h = 250.00$$

$$A_g = 750000.00$$

$$\text{From (12.9), ACI 440: } k_a = 0.00364754$$

$$g = p_t + p_c + p_v = 0.0101699$$

$$r_c = 40.00$$

$$A_e / A_c = 0.52524587$$

$$\text{Effective FRP thickness, } t_f = N L \cdot t \cdot \text{Cos}(b_1) = 1.016$$

$$\text{effective strain from (12.5) and (12.12), } e_{fe} = 0.004$$

$$f_u = 0.01$$

$$E_f = 64828.00$$

$$E_c = 21019.039$$

$$y = 0.2589268$$

$$A = 0.00999806$$

$$B = 0.00611172$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio  $I_b / I_d$

$$\text{Lap Length: } I_d / I_d, \text{min} = 0.39548208$$

$$I_b = 300.00$$

$$I_d = 758.5679$$

Calculation of  $I$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

$$\text{Mean strength value of all re-bars: } f_y = 400.00$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

- Calculation of  $p$  -

Considering wall controlled by flexure (shear control ratio  $\leq 1$ ),  
from table 10-19:  $p = 0.015$

with:

- Condition i (shear wall and wall segments)

-  $(A_s - A_s') \cdot f_y + P / (t_w \cdot l_w \cdot f_c') = -0.20908486$

$A_s = 0.00$

$A_s' = 6346.017$

$f_y = 400.00$

$P = 29388.501$

$t_w = 3000.00$

$l_w = 250.00$

$f_c' = 16.00$

-  $V / (t_w \cdot l_w \cdot f_c'^{0.5}) = 2.5633503E-020$ , NOTE: units in lb & in

- Confined Boundary: No

Boundary hoops spacing exceed  $8d_b$  ( $s_1 > 8 \cdot d_b$  or  $s_2 > 8 \cdot d_b$ )

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:

$V_{w1} = 83775.804$

$s_1 = 150.00$

Boundary Element 2:

$V_{w2} = 83775.804$

$s_2 = 150.00$

Grid Shear Force,  $V_{w3} = 0.00$

Concrete Shear Force,  $V_c = 124725.901$

(The variables above have already been given in Shear control ratio calculation)

Mean diameter of all bars,  $d_b = 17.33333$

Design Shear Force,  $V = 6.3856629E-015$

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: Collapse Prevention (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: (d)

Section Type: rcrws

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

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,  $M_a = -8.3458925E-011$

Shear Force,  $V_a = -6.3856629E-015$

EDGE -B-

Bending Moment,  $M_b = 6.1924294E-011$

Shear Force,  $V_b = 6.3856629E-015$

BOTH EDGES

Axial Force,  $F = -29388.501$

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  $V_R = V_n = 267143.455$

From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_n < 0.83 \cdot f_c'^{0.5} \cdot h \cdot d = 314286.417$

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:  $V_c = 126390.829$

$M_u/V_u - l_w/2 = 9572.395 > 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$M_u = 6.1924294E-011$

$V_u = 6.3856629E-015$

$N_u = 29388.501$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

$V_{s3} = 0.00$  is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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  $\theta$  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  $\alpha_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$  (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: (d)

## Calculation No. 14

wall W1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

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: rcw/s

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####

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 = 1.00406

Element Length,  $L = 3000.00$

Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
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,  $V_a = 6.3108872E-029$   
EDGE -B-  
Shear Force,  $V_b = -6.3108872E-029$   
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 ,  $V_e/V_r = 1.01783$   
Member Controlled by Shear ( $V_e/V_r > 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 3.0413E+009$   
 $\mu_{u1+} = 2.8453E+009$ , 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  
 $\mu_{u1-} = 3.0413E+009$ , 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  
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 3.0413E+009$   
 $\mu_{u2+} = 2.8453E+009$ , 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  
 $\mu_{u2-} = 3.0413E+009$ , 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 $\mu_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 2.2735554E-006$$

$$M_u = 2.8453E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where  $f = a_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{f} = 0.015$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h,1} = 150.00$$

$$b_{o,1} = 190.00$$

$$h_{o,1} = 540.00$$

$$b_{i2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h,2} = 150.00$$

$$b_{o,2} = 190.00$$

$$h_{o,2} = 540.00$$

$$b_{i2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirrups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$ps2,y \text{ (column 2)} = (As2 \cdot h2 / s_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

$$As2 = Astir2 \cdot ns2 = 157.0796$$

$$\text{No stirups, } ns2 = 2.00$$

$$ps3,y \text{ (web)} = (As3 \cdot h3 / s_3) / Ac = 0.00$$

$$h3 = 250.00$$

$$As3 = Astir3 \cdot ns3 = 157.0796$$

$$\text{No stirups, } ns3 = 0.00$$

$$Asec = 750000.00$$

$$s_1 = 150.00$$

$$s_2 = 150.00$$

$$s_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

$$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/d = 0.31638566$$

$$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08066667,$$

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = fs = 290.1959$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00120915$$

$$sh2 = 0.00467215$$

$$ft2 = 348.235$$

$$fy2 = 290.1959$$

$$su2 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.31638566$$

$$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esu2\_nominal = 0.08066667,$$

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = fs = 290.1959$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00120915$$

$$shv = 0.00467215$$

$$ftv = 348.235$$

$$fyv = 290.1959$$

$$suv = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/d = 0.31638566$$

$$suv = 0.4 \cdot esuv\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esuv\_nominal = 0.08066667,$$

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = fs = 290.1959$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.07029503$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07029503$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 16.06499$$

$$c_c (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09344146$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09344146$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.13770595$$

$$M_u = M_{Rc} (4.14) = 2.8453E+009$$

$$u = s_u (4.1) = 2.2735554E-006$$

-----  
Calculation of ratio  $l_b/d$

-----  
Lap Length:  $l_b/d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $M_{u1}$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2880917E-006$$

$$M_u = 3.0413E+009$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o (5A.5, TBDY) = 0.002$$

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:  $c_u = 0.0035$

$$w_e ((5.4c), TBDY) = a_{se} * s_{h,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

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,  $tf = NL*t*\cos(b1) = 1.016$   
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 = 150.00  
bo\_1 = 190.00  
ho\_1 = 540.00  
bi2\_1 = 655400.00  
ase2 = 0.00  
sh\_2 = 150.00  
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) = 0.00069813  
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x = ps1,x + ps2,x + ps3,x = 0.00356047  
ps1,x (column 1) =  $(As1*h1/s_1)/Ac = 0.00083776$   
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,x (column 2) =  $(As2*h2/s_2)/Ac = 0.00083776$   
h2 = 600.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,x (web) =  $(As3*h3/s_3)/Ac = 0.00188496$   
h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirrups, ns3 = 2.00

psh,y = ps1,y + ps2,y + ps3,y = 0.00069813  
ps1,y (column 1) =  $(As1*h1/s_1)/Ac = 0.00034907$   
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirrups, ns1 = 2.00  
ps2,y (column 2) =  $(As2*h2/s_2)/Ac = 0.00034907$   
h2 = 250.00  
As2 = Astir2\*ns2 = 157.0796  
No stirrups, ns2 = 2.00  
ps3,y (web) =  $(As3*h3/s_3)/Ac = 0.00$   
h3 = 250.00  
As3 = Astir3\*ns3 = 157.0796  
No stirrups, ns3 = 0.00

Asec = 750000.00  
s\_1 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00  
From ((5.A5), TBDY), TBDY: cc = 0.00204062

$c = \text{confinement factor} = 1.00406$   
 $y1 = 0.00120915$   
 $sh1 = 0.00467215$   
 $ft1 = 348.235$   
 $fy1 = 290.1959$   
 $su1 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.31638566$   
 $su1 = 0.4 * esu1\_nominal ((5.5), \text{TBDY}) = 0.03226667$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08066667$ ,  
 For 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  $fs1 = fs = 290.1959$   
 with  $Es1 = Es = 200000.00$   
 $y2 = 0.00120915$   
 $sh2 = 0.00467215$   
 $ft2 = 348.235$   
 $fy2 = 290.1959$   
 $su2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/lb,min = 0.31638566$   
 $su2 = 0.4 * esu2\_nominal ((5.5), \text{TBDY}) = 0.03226667$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08066667$ ,  
 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  $fs2 = fs = 290.1959$   
 with  $Es2 = Es = 200000.00$   
 $yv = 0.00120915$   
 $shv = 0.00467215$   
 $ftv = 348.235$   
 $fyv = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv\_nominal ((5.5), \text{TBDY}) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 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  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.07029503$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.07029503$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.01510726$   
 and confined core properties:  
 $b = 190.00$   
 $d = 2927.00$   
 $d' = 13.00$   
 $fcc (5A.2, \text{TBDY}) = 16.06499$   
 $cc (5A.5, \text{TBDY}) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.09344146$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.09344146$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.02008172$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.14318411$$

$$M_u = M_{Rc}(4.14) = 3.0413E+009$$

$$u = s_u(4.1) = 2.2880917E-006$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Lap Length:  $l_b/l_d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

$$\text{Mean strength value of all re-bars: } f_y = 500.00$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
-----  
-----  
Calculation of  $M_u2+$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2735554E-006$$

$$M_u = 2.8453E+009$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0035$$

$$w_e((5.4c), \text{TBDY}) = a_{se} * s_{h, \min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$$

where  $f = a_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

-----  
 $f_x = 0.00$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{fe} = 636.1644$$

-----  
 $f_y = 0.00$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f/b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{fe} = 944.3987$$

-----  
 $R = 40.00$

$$\text{Effective FRP thickness, } t_f = NL * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$ase((5.4d), TBDY) = (ase1 * Acol1 + ase2 * Acol2 + ase3 * Aweb) / Asec = 0.00$$

$$ase1 = 0.00$$

$$sh_1 = 150.00$$

$$bo_1 = 190.00$$

$$ho_1 = 540.00$$

$$bi2_1 = 655400.00$$

$$ase2 = 0.00$$

$$sh_2 = 150.00$$

$$bo_2 = 190.00$$

$$ho_2 = 540.00$$

$$bi2_2 = 655400.00$$

$$ase3 = 0 \text{ (grid does not provide confinement)}$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$$

$$ps1,x \text{ (column 1)} = (As1 * h1 / s_1) / Ac = 0.00083776$$

$$h1 = 600.00$$

$$As1 = Astir1 * ns1 = 157.0796$$

No stirrups, ns1 = 2.00

$$ps2,x \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.00083776$$

$$h2 = 600.00$$

$$As2 = Astir2 * ns2 = 157.0796$$

No stirrups, ns2 = 2.00

$$ps3,x \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00188496$$

$$h3 = 1800.00$$

$$As3 = Astir3 * ns3 = 0.00$$

No stirrups, ns3 = 2.00

$$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$$

$$ps1,y \text{ (column 1)} = (As1 * h1 / s_1) / Ac = 0.00034907$$

$$h1 = 250.00$$

$$As1 = Astir1 * ns1 = 157.0796$$

No stirrups, ns1 = 2.00

$$ps2,y \text{ (column 2)} = (As2 * h2 / s_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

$$As2 = Astir2 * ns2 = 157.0796$$

No stirrups, ns2 = 2.00

$$ps3,y \text{ (web)} = (As3 * h3 / s_3) / Ac = 0.00$$

$$h3 = 250.00$$

$$As3 = Astir3 * ns3 = 157.0796$$

No stirrups, ns3 = 0.00

$$Asec = 750000.00$$

$$s_1 = 150.00$$

$$s_2 = 150.00$$

$$s_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/d = 0.31638566$$

$$su1 = 0.4 * esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

$$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08066667,$$

For 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.

$$\text{with } fs1 = fs = 290.1959$$

with  $E_s1 = E_s = 200000.00$   
 $y_2 = 0.00120915$   
 $sh_2 = 0.00467215$   
 $ft_2 = 348.235$   
 $fy_2 = 290.1959$   
 $su_2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/lb_{u,min} = 0.31638566$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08066667$ ,  
 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  $fs_2 = fs = 290.1959$   
 with  $E_s2 = E_s = 200000.00$   
 $y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348.235$   
 $fy_v = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08066667$ ,  
 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  $fsv = fs = 290.1959$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.07029503$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.07029503$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.00$

and confined core properties:

$b = 190.00$   
 $d = 2927.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.09344146$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.09344146$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < v_s, y_2$  - LHS eq.(4.5) is satisfied

---

$su (4.9) = 0.13770595$   
 $Mu = MRc (4.14) = 2.8453E+009$   
 $u = su (4.1) = 2.2735554E-006$

-----  
 Calculation of ratio  $lb/ld$   
 -----

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$

s = 0.80  
e = 1.00  
cb = 25.00  
Ktr = 2.24399  
n = 28.00

-----  
-----  
-----  
Calculation of Mu2-

-----  
-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

u = 2.2880917E-006  
Mu = 3.0413E+009

-----  
with full section properties:

b = 250.00  
d = 2957.00  
d' = 43.00  
v = 0.00232618  
N = 27514.027

fc = 16.00

co (5A.5, TBDY) = 0.002

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)

From (5.4b), TBDY:  $\phi_u = 0.0035$

$\phi_{we}$  ((5.4c), TBDY) =  $\text{ase} * \text{sh}_{,\text{min}} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi = \text{af} * \text{pf} * \text{ffe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

-----  
 $\phi_x = 0.00$

$\text{af} = 0.00$

b = 250.00

h = 3000.00

From EC8 A.4.4.3(6),  $\text{pf} = 2t_f / b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35),  $\text{ff},e = 636.1644$

-----  
 $\phi_y = 0.00$

$\text{af} = 0.00$

b = 3000.00

h = 250.00

From EC8 A.4.4.3(6),  $\text{pf} = 2t_f / b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $\text{ff},e = 944.3987$

-----  
R = 40.00

Effective FRP thickness,  $t_f = \text{NL} * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\text{ase}$  ((5.4d), TBDY) =  $(\text{ase}_1 * A_{\text{col}1} + \text{ase}_2 * A_{\text{col}2} + \text{ase}_3 * A_{\text{web}}) / A_{\text{sec}} = 0.00$

$\text{ase}_1 = 0.00$

$\text{sh}_1 = 150.00$

$\text{bo}_1 = 190.00$

$\text{ho}_1 = 540.00$

$\text{bi}_{2,1} = 655400.00$

$\text{ase}_2 = 0.00$

$\text{sh}_2 = 150.00$

$\text{bo}_2 = 190.00$

$\text{ho}_2 = 540.00$

$\text{bi}_{2,2} = 655400.00$

$\text{ase}_3 = 0$  (grid does not provide confinement)

$\text{psh}_{,\text{min}} = \text{Min}(\text{psh}_x, \text{psh}_y) = 0.00069813$

Expression ((5.4d), TBDY) for  $\text{psh}_{,\text{min}}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
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 = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_b,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with  $E_s = E_s = 200000.00$   
 $y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348.235$   
 $fy_v = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 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  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07029503$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.07029503$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01510726$   
 and confined core properties:  
 $b = 190.00$   
 $d = 2927.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09344146$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.09344146$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02008172$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.24399$   
 $n = 28.00$

-----

Calculation of Shear Strength  $V_r = Min(V_{r1}, V_{r2}) = 1.9920E+006$

Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920E+006$   
 From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r1} = V_n < 0.83 * fc' ^{0.5} * h * d$

NOTE: In expression (22.5.1.1) ' $V_w$ ' is replaced by ' $V_{w+} + f * V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$   
 $\mu_u/V_u - l_w/2 = 0.00 \leq 0$   
 = 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 250.00$   
 $d = 2400.00$   
 $l_w = 3000.00$   
 $\mu_u = 2.8012401E-010$   
 $V_u = 6.3108872E-029$   
 $N_u = 27514.027$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$   
 $V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:  
 $d = 480.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:  
 $d = 480.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s2}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_{s3} = 452389.342$  is calculated for web, with:  
 $d = 1440.00$   
 $A_v = 157079.633$   
 $s = 200.00$   
 $f_y = 400.00$   
 $V_{s3}$  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:  $\theta = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, a_1)|, |V_f(-45, a_1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.016$   
 $d_{fv} = d$  (figure 11.2, ACI 440) =  $2957.00$   
 $f_{fe}$  ((11-5), 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:  $V_s + V_f \leq 1.5943E+006$   
 $b_w = 250.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920E+006$   
 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) '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:  $V_c = 653502.805$   
 $\mu_u/V_u - l_w/2 = 0.00 \leq 0$   
 = 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 250.00$   
 $d = 2400.00$   
 $l_w = 3000.00$   
 $\mu_u = 2.8012401E-010$   
 $V_u = 6.3108872E-029$   
 $N_u = 27514.027$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$   
 $V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:  
 $d = 480.00$

Av = 157079.633

s = 150.00

fy = 400.00

Vs1 has been multiplied by 1 (s<d/2, according to ASCE 41-17,10.3.4)

Vs2 = 201061.93 is calculated for pseudo-Column 2, with:

d = 480.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs2 has been multiplied by 1 (s<d/2, according to ASCE 41-17,10.3.4)

Vs3 = 452389.342 is calculated for web, with:

d = 1440.00

Av = 157079.633

s = 200.00

fy = 400.00

Vs3 has been multiplied by 1 (s<d/2, according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 1.5581E+006

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sin + cos is replaced with (cot + cota)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) = 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 <= 1.5943E+006

bw = 250.00

-----  
End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcrcws

Constant Properties

-----  
Knowledge Factor, = 0.85

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, fc = fcm = 16.00

Existing material of Secondary Member: Steel Strength, fs = fsm = 400.00

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, fs = 1.25\*fsm = 500.00

#####

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 = 1.00406

Element Length, L = 3000.00

Secondary Member

Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
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: 2  
EDGE -A-  
Shear Force,  $V_a = 0.00$   
EDGE -B-  
Shear Force,  $V_b = 0.00$   
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,  $V_e/V_r = 0.14054053$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7738E+008$   
 $Mu_{1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7738E+008$   
 $Mu_{2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $Mu_{2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

#### Calculation of $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 3.4223799E-005$   
 $Mu = 1.4516E+008$

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)

$$f_x = 0.00$$

$$a_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$f_y = 0.00$$

$$a_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{col1} + a_{se2} * A_{col2} + a_{se3} * A_{web}) / A_{sec} = 0.00$$

$$a_{se1} = 0.00$$

$$s_{h,1} = 150.00$$

$$b_{o,1} = 190.00$$

$$h_{o,1} = 540.00$$

$$b_{i2,1} = 655400.00$$

$$a_{se2} = 0.00$$

$$s_{h,2} = 150.00$$

$$b_{o,2} = 190.00$$

$$h_{o,2} = 540.00$$

$$b_{i2,2} = 655400.00$$

$$a_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,\min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $p_{sh,\min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_{,3}) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

$$A_{s3} = A_{stir3} * n_{s3} = 0.00$$

$$\text{No stirrups, } n_{s3} = 2.00$$

$$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$$

$$p_{s1,y} \text{ (column 1)} = (A_{s1} * h_1 / s_{,1}) / A_c = 0.00034907$$

$$h_1 = 250.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$p_{s2,y} \text{ (column 2)} = (A_{s2} * h_2 / s_{,2}) / A_c = 0.00034907$$

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 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y2, sh2,ft2,fy2, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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.

yv, shv,ftv,fyv, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$   
 and confined core properties:  
 $b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08209659$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08209659$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.00$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18563201$   
 $Mu = MRc (4.14) = 1.4516E+008$   
 $u = su (4.1) = 3.4223799E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Lap Length:  $l_b/l_d = 0.31638566$   
 $l_b = 300.00$   
 $l_d = 948.2098$   
 Calculation of  $l_b,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $f_y = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.24399$   
 $n = 28.00$

-----  
 Calculation of  $Mu1$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 3.5153739E-005$   
 $Mu = 1.7738E+008$   
 -----

with full section properties:

$b = 3000.00$   
 $d = 208.00$   
 $d' = 42.00$   
 $v = 0.00275581$   
 $N = 27514.027$   
 $f_c = 16.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0035$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.0035$   
 $w_e ((5.4c), TBDY) = a_{se} * sh_{,min} * f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$   
 where  $f = a_f * p_f * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

-----  
 $f_x = 0.00$   
 $a_f = 0.00$   
 $b = 250.00$   
 $h = 3000.00$   
 From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.008128$   
 $bw = 250.00$

effective stress from (A.35),  $f_{f,e} = 636.1644$

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35),  $f_{f,e} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL*t*\cos(b1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_f = 0.015$

$a_{se} ((5.4d), TBDY) = (a_{se1}*A_{col1} + a_{se2}*A_{col2} + a_{se3}*A_{web})/A_{sec} = 0.00$

$a_{se1} = 0.00$

$sh_1 = 150.00$

$bo_1 = 190.00$

$ho_1 = 540.00$

$bi2_1 = 655400.00$

$a_{se2} = 0.00$

$sh_2 = 150.00$

$bo_2 = 190.00$

$ho_2 = 540.00$

$bi2_2 = 655400.00$

$a_{se3} = 0$  (grid does not provide confinement)

$p_{sh,min} = \min(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1}*h_1/s_1)/A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1}*n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2}*h_2/s_2)/A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2}*n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,x}$  (web) =  $(A_{s3}*h_3/s_3)/A_c = 0.00188496$

$h_3 = 1800.00$

$A_{s3} = A_{stir3}*n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1}*h_1/s_1)/A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1}*n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2}*h_2/s_2)/A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2}*n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3}*h_3/s_3)/A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3}*n_{s3} = 157.0796$

No stirrups,  $n_{s3} = 0.00$

$A_{sec} = 750000.00$

$s_1 = 150.00$

$s_2 = 150.00$

$s_3 = 200.00$

$f_{ywe} = 500.00$

$f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$

$c$  = confinement factor = 1.00406

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/d = 0.31638566$   
 $su_1 = 0.4*esu_1,nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_1,nominal = 0.08066667$ ,  
 For calculation of  $esu_1,nominal$  and  $y_1, sh_1,ft_1,fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1,ft_1,fy_1$ , are also multiplied by  $Min(1,1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = fs = 290.1959$   
 with  $Es_1 = Es = 200000.00$

$y_2 = 0.00120915$   
 $sh_2 = 0.00467215$   
 $ft_2 = 348.235$   
 $fy_2 = 290.1959$   
 $su_2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/lb,min = 0.31638566$   
 $su_2 = 0.4*esu_2,nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_2,nominal = 0.08066667$ ,  
 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  $Min(1,1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = fs = 290.1959$   
 with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348.235$   
 $fy_v = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/d = 0.31638566$   
 $suv = 0.4*esuv,nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv,nominal = 0.08066667$ ,  
 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  $Min(1,1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$

$1 = Asl,ten/(b*d)*(fs_1/fc) = 0.06885062$   
 $2 = Asl,com/(b*d)*(fs_2/fc) = 0.06885062$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04675268$

and confined core properties:

$b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten/(b*d)*(fs_1/fc) = 0.08209659$   
 $2 = Asl,com/(b*d)*(fs_2/fc) = 0.08209659$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
 --->

su (4.9) = 0.20717489  
Mu = MRc (4.14) = 1.7738E+008  
u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Lap Length: lb/l<sub>d</sub> = 0.31638566

lb = 300.00

l<sub>d</sub> = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: f<sub>y</sub> = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 2.24399

n = 28.00

-----  
-----  
Calculation of Mu<sub>2+</sub>

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

u = 3.4223799E-005

Mu = 1.4516E+008

-----  
with full section properties:

b = 3000.00

d = 208.00

d' = 42.00

v = 0.00275581

N = 27514.027

f<sub>c</sub> = 16.00

co (5A.5, TBDY) = 0.002

Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu, \mu_c) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu = 0.0035$

we ((5.4c), TBDY) =  $\text{ase} * \text{sh}_{\text{min}} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \text{af} * \text{pf} * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

-----  
f<sub>x</sub> = 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<sub>y</sub> = 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

f<sub>u,f</sub> = 1055.00

E<sub>f</sub> = 64828.00

u<sub>f</sub> = 0.015

ase ((5.4d), TBDY) = (ase1\*Acol1 + ase2\*Acol2 + ase3\*Aweb)/Asec = 0.00

ase1 = 0.00  
sh\_1 = 150.00  
bo\_1 = 190.00  
ho\_1 = 540.00  
bi2\_1 = 655400.00

ase2 = 0.00  
sh\_2 = 150.00  
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) = 0.00069813

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) =  $(As1 \cdot h1 / s_1) / Ac = 0.00083776$   
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) =  $(As2 \cdot h2 / s_2) / Ac = 0.00083776$   
h2 = 600.00  
As2 = Astir2\*ns2 = 157.0796  
No stirups, ns2 = 2.00  
ps3,x (web) =  $(As3 \cdot h3 / s_3) / Ac = 0.00188496$   
h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) =  $(As1 \cdot h1 / s_1) / Ac = 0.00034907$   
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) =  $(As2 \cdot h2 / s_2) / Ac = 0.00034907$   
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 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 =  $0.4 \cdot esu1\_nominal$  ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

$y_2 = 0.00120915$   
 $sh_2 = 0.00467215$   
 $ft_2 = 348.235$   
 $fy_2 = 290.1959$   
 $su_2 = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/lb_{min} = 0.31638566$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08066667$ ,  
 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  $fs_2 = fs = 290.1959$   
 with  $Es_2 = Es = 200000.00$   
 $yv = 0.00120915$   
 $shv = 0.00467215$   
 $ftv = 348.235$   
 $fyv = 290.1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08066667$ ,  
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 290.1959$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.06885062$   
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.06885062$   
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$   
 and confined core properties:  
 $b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $fcc (5A.2, TBDY) = 16.06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.08209659$   
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.08209659$   
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18563201$   
 $Mu = MRc (4.14) = 1.4516E+008$   
 $u = su (4.1) = 3.4223799E-005$

-----  
 Calculation of ratio  $lb/ld$   
 -----

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300.00$   
 $ld = 948.2098$   
 Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16.85714$   
 Mean strength value of all re-bars:  $fy = 500.00$   
 $t = 1.00$   
 $s = 0.80$

e = 1.00  
cb = 25.00  
Ktr = 2.24399  
n = 28.00

-----  
-----  
-----  
Calculation of Mu2-

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 3.5153739E-005$   
Mu = 1.7738E+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  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.0035$

$\mu_{cc}$  ((5.4c), TBDY) =  $\text{ase} * \text{sh}_{\min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \text{af} * \text{pf} * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

-----  
 $f_x = 0.00$

$\text{af} = 0.00$

b = 250.00

h = 3000.00

From EC8 A.4.4.3(6),  $\text{pf} = 2t_f / b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35),  $f_{fe} = 636.1644$

-----  
 $f_y = 0.00$

$\text{af} = 0.00$

b = 3000.00

h = 250.00

From EC8 A.4.4.3(6),  $\text{pf} = 2t_f / b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $f_{fe} = 944.3987$

-----  
R = 40.00

Effective FRP thickness,  $t_f = N L * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{f} = 0.015$

$\text{ase}$  ((5.4d), TBDY) =  $(\text{ase}_1 * A_{col1} + \text{ase}_2 * A_{col2} + \text{ase}_3 * A_{web}) / A_{sec} = 0.00$

$\text{ase}_1 = 0.00$

$\text{sh}_1 = 150.00$

$\text{bo}_1 = 190.00$

$\text{ho}_1 = 540.00$

$\text{bi}_{2,1} = 655400.00$

$\text{ase}_2 = 0.00$

$\text{sh}_2 = 150.00$

$\text{bo}_2 = 190.00$

$\text{ho}_2 = 540.00$

$\text{bi}_{2,2} = 655400.00$

$\text{ase}_3 = 0$  (grid does not provide confinement)

$\text{psh}_{\min} = \text{Min}(\text{psh}_x, \text{psh}_y) = 0.00069813$

Expression ((5.4d), TBDY) for  $\text{psh}_{\min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $\text{psh}_x = \text{ps}_{1,x} + \text{ps}_{2,x} + \text{ps}_{3,x} = 0.00356047$

ps1,x (column 1) =  $(As1 \cdot h1 / s_1) / Ac = 0.00083776$   
h1 = 600.00  
As1 = Astir1 \* ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) =  $(As2 \cdot h2 / s_2) / Ac = 0.00083776$   
h2 = 600.00  
As2 = Astir2 \* ns2 = 157.0796  
No stirups, ns2 = 2.00  
ps3,x (web) =  $(As3 \cdot h3 / s_3) / Ac = 0.00188496$   
h3 = 1800.00  
As3 = Astir3 \* ns3 = 0.00  
No stirups, ns3 = 2.00

psh,y = ps1,y + ps2,y + ps3,y = 0.00069813  
ps1,y (column 1) =  $(As1 \cdot h1 / s_1) / Ac = 0.00034907$   
h1 = 250.00  
As1 = Astir1 \* ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) =  $(As2 \cdot h2 / s_2) / Ac = 0.00034907$   
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00

fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.31638566

su1 =  $0.4 \cdot esu1\_nominal$  ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 =  $0.4 \cdot esu2\_nominal$  ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

$y_v = 0.00120915$   
 $sh_v = 0.00467215$   
 $ft_v = 348,235$   
 $fy_v = 290,1959$   
 $suv = 0.00579712$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 0.31638566$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 290,1959$   
 with  $Esv = Es = 200000,00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.06885062$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.06885062$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04675268$

and confined core properties:

$b = 2940,00$   
 $d = 178,00$   
 $d' = 12,00$   
 $fcc (5A.2, TBDY) = 16,06499$   
 $cc (5A.5, TBDY) = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.08209659$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.08209659$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.20717489$   
 $Mu = MRc (4.14) = 1.7738E+008$   
 $u = su (4.1) = 3.5153739E-005$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$   
 $lb = 300,00$   
 $ld = 948,2098$   
 Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$   
 $db = 16,85714$   
 Mean strength value of all re-bars:  $fy = 500,00$   
 $t = 1,00$   
 $s = 0,80$   
 $e = 1,00$   
 $cb = 25,00$   
 $Ktr = 2,24399$   
 $n = 28,00$

Calculation of Shear Strength  $Vr = Min(Vr1, Vr2) = 841398.394$

Calculation of Shear Strength at edge 1,  $Vr1 = 841398.394$   
 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:  $V_c = 653502.805$

$\mu_u/V_u - l_w/2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 1.9099438E-011$

$V_u = 0.00$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

$V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

$V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:

$d = 200.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$2(1-s/d) = 0.50$

$V_{s3} = 0.00$  is calculated for web, with:

$d = 200.00$

$A_v = 0.00$

$s = 200.00$

$f_y = 400.00$

$V_{s3}$  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  $V_f(\theta, a)$ , 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:  $\theta = 45^\circ$  and  $a = 90^\circ$

$V_f = \text{Min}(|V_f(45, 90)|, |V_f(-45, 90)|)$ , with:

total thickness per orientation,  $t_f = N_L * t / N_{Dir} = 1.016$

$d_{fv} = d$  (figure 11.2, ACI 440) = 208.00

$f_{fe}$  ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.01$

From (11-11), ACI 440:  $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 841398.394$

From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r2} = V_n < 0.83 * f_c'^{0.5} * h * d$

NOTE: In expression (22.5.1.1) ' $V_w$ ' is replaced by ' $V_w + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$

$\mu_u/V_u - l_w/2 = 0.00 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$h = 3000.00$

$d = 200.00$

$l_w = 250.00$

$\mu_u = 1.9099438E-011$

$V_u = 0.00$

$N_u = 27514.027$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$

Vs1 = 41887.902 is calculated for pseudo-Column 1, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs1 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs2 = 41887.902 is calculated for pseudo-Column 2, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs2 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs3 = 0.00 is calculated for web, with:

d = 200.00

Av = 0.00

s = 200.00

fy = 400.00

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)  $\sin \alpha + \cos \alpha$  is replaced with  $(\cot \alpha + \cot \alpha) \sin \alpha$  which is more a generalised expression, where  $\alpha$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(  $\alpha$  ), 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,  $\alpha$ )|, |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: 2

Integration Section: (a)

Section Type: rcrws

Constant Properties

-----  
Knowledge Factor,  $\lambda = 0.85$

According to 10.7.2.3, ASCE 41-17, shear walls with

transverse reinforcement percentage,  $\lambda < 0.0015$

are considered Force-Controlled and lower-bound strengths are used according to 7.5.1.3, ASCE 41-17

$\lambda = 0.00069813$

-----  
with  $\lambda = \lambda_1 + \lambda_2 + \lambda_3$ , being the shear reinf. ratio in a plane perpendicular to the shear axis 3

(pseudo-col.1  $\lambda_1 = A_{s1} * b_1 / s_1 = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$s_1 = 150.00$

total area of hoops perpendicular to shear axis,  $A_{s1} = 157.0796$

(pseudo-col.2  $\lambda_2 = A_{s2} * b_2 / s_2 = (A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$s_2 = 150.00$

total area of hoops perpendicular to shear axis,  $A_{s2} = 157.0796$

(grid ps3 =  $As3 \cdot b3 / s3 = (As3 \cdot h3 / s3) / Ac = 0.00$   
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 Secondary Member: Concrete Strength,  $fc = fc\_lower\_bound = 16.00$   
Existing material of Secondary Member: Steel Strength,  $fs = fs\_lower\_bound = 400.00$   
Concrete Elasticity,  $Ec = 21019.039$   
Steel Elasticity,  $Es = 200000.00$   
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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $lb = 300.00$   
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,  $F = -29388.501$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $Asl = 0.00$   
-Compression:  $Asc = 6346.017$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $Asl,ten = 2865.133$   
-Compression:  $Asl,com = 2865.133$   
-Middle:  $Asl,mid = 615.7522$   
Mean Diameter of Tension Reinforcement,  $DbL = 17.33333$

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  $u,R = * u = 0.02$   
from table 10-20:  $u = 0.02352941$

with:

- Condition i (shear wall and wall segments)  
-  $(As - As') \cdot fy + P / (tw \cdot lw \cdot fc) = -0.20908486$   
 $As = 0.00$   
 $As' = 6346.017$   
 $fy = 400.00$   
 $P = 29388.501$   
 $tw = 250.00$   
 $lw = 3000.00$   
 $fc = 16.00$

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: Collapse Prevention (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: (d)  
Section Type: rcrws

Constant Properties

Knowledge Factor,  $\gamma = 0.85$   
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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

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,  $M_a = 8.5315E+007$

Shear Force,  $V_a = -28549.607$

EDGE -B-

Bending Moment,  $M_b = 348518.893$

Shear Force,  $V_b = 28549.607$

BOTH EDGES

Axial Force,  $F = -29388.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 6346.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 2865.133$

-Compression:  $A_{st,com} = 2865.133$

-Middle:  $A_{st,mid} = 615.7522$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.33333$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = V_n = 1.6932E+006$

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:  $V_c = 653877.70$

$\mu_u / \nu_u - l_w / 2 = -1487.793 \leq 0$

= 1 (normal-weight concrete)

$f_c' = 16.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$h = 250.00$

$d = 2400.00$

$l_w = 3000.00$

$M_u = 348518.893$

$V_u = 28549.607$

$N_u = 29388.501$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$d = 480.00$

$A_v = 157079.633$

$s = 150.00$

$f_y = 400.00$

$V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$d = 480.00$

$A_v = 157079.633$

$$s = 150.00$$

$$f_y = 400.00$$

Vs2 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

Vs3 = 452389.342 is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

Vs3 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$$V_f((11-3)-(11.4), \text{ACI 440}) = 1.5581\text{E}+006$$

$$f = 0.95, \text{ for fully-wrapped sections}$$

$w_f/s_f = 1$  (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  $\theta$  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  $\alpha_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta = b1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|), \text{ with:}$$

$$\text{total thickness per orientation, } t_{f1} = N_L * t / N_{oDir} = 1.016$$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 2957.00$$

$$f_{fe}((11-5), \text{ACI 440}) = 259.312$$

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.01$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943\text{E}+006$$

$$b_w = 250.00$$

-----  
End Of Calculation of Shear Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (d)  
-----

## Calculation No. 16

wall W1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####  
 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 = 1.00406  
 Element Length,  $L = 3000.00$

Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Lap Length  $l_o = 300.00$   
 FRP Wrapping Data  
 Type: Carbon  
 Cured laminate properties (design values)  
 Thickness,  $t = 1.016$   
 Tensile Strength,  $f_{fu} = 1055.00$   
 Tensile Modulus,  $E_f = 64828.00$   
 Elongation,  $e_{fu} = 0.01$   
 Number of directions,  $NoDir = 1$   
 Fiber orientations,  $b_i: 0.00^\circ$   
 Number of layers,  $NL = 1$   
 Radius of rounding corners,  $R = 40.00$

-----  
 Stepwise Properties

-----  
 At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = 6.3108872E-029$   
 EDGE -B-  
 Shear Force,  $V_b = -6.3108872E-029$

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,  $V_e/V_r = 1.01783$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 2.0275E+006$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.0413E+009$

$M_{u1+} = 2.8453E+009$ , 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

$M_{u1-} = 3.0413E+009$ , 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.0413E+009$

$M_{u2+} = 2.8453E+009$ , 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

$M_{u2-} = 3.0413E+009$ , 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  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.2735554E-006$

$M_u = 2.8453E+009$

with full section properties:

$b = 250.00$

$d = 2957.00$

$d' = 43.00$

$v = 0.00232618$

$N = 27514.027$

$f_c = 16.00$

$\alpha_{co}$  (5A.5, TBDY) = 0.002

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)

From (5.4b), TBDY:  $\phi_u = 0.0035$

$\phi_{we}$  ((5.4c), TBDY) =  $\alpha_{se} * \phi_{sh,min} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi = \alpha_f * \phi_{pf} * f_{fe} / f_{ce}$  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,  $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase((5.4d), TBDY) = (ase_1 \cdot A_{col1} + ase_2 \cdot A_{col2} + ase_3 \cdot A_{web}) / A_{sec} = 0.00$   
 $ase_1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $ase_2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$

$ase_3 = 0$  (grid does not provide confinement)  
 $psh_{,min} = \min(psh_x, psh_y) = 0.00069813$   
Expression ((5.4d), TBDY) for  $psh_{,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x}$  (column 1) =  $(As_1 \cdot h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x}$  (column 2) =  $(As_2 \cdot h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$   
No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x}$  (web) =  $(As_3 \cdot h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $As_3 = Astir_3 \cdot ns_3 = 0.00$   
No stirrups,  $ns_3 = 2.00$

$psh_y = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y}$  (column 1) =  $(As_1 \cdot h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $As_1 = Astir_1 \cdot ns_1 = 157.0796$   
No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y}$  (column 2) =  $(As_2 \cdot h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $As_2 = Astir_2 \cdot ns_2 = 157.0796$   
No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y}$  (web) =  $(As_3 \cdot h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $As_3 = Astir_3 \cdot ns_3 = 157.0796$   
No stirrups,  $ns_3 = 0.00$

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c =$  confinement factor = 1.00406

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $lo/lo_{,min} = lb/ld = 0.31638566$

$$su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_1\_nominal = 0.08066667$ ,

For calculation of  $esu_1\_nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_1 = fs = 290.1959$

with  $Es_1 = Es = 200000.00$

$$y_2 = 0.00120915$$

$$sh_2 = 0.00467215$$

$$ft_2 = 348.235$$

$$fy_2 = 290.1959$$

$$su_2 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{ou,min} = lb/lb_{min} = 0.31638566$$

$$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_2\_nominal = 0.08066667$ ,

For calculation of  $esu_2\_nominal$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{ou,min} = lb/ld = 0.31638566$$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Es_v = Es = 200000.00$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.07029503$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.07029503$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.09344146$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.09344146$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied

---

$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

Calculation of ratio  $lb/ld$

$$\text{Lap Length: } lb/ld = 0.31638566$$

$$lb = 300.00$$

ld = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.24399

n = 28.00

-----  
-----  
-----  
Calculation of Mu1-

-----  
-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.2880917E-006$

Mu = 3.0413E+009

-----  
with full section properties:

b = 250.00

d = 2957.00

d' = 43.00

v = 0.00232618

N = 27514.027

fc = 16.00

co (5A.5, TBDY) = 0.002

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)

From (5.4b), TBDY:  $\phi_u = 0.0035$

$\phi_{we}$  ((5.4c), TBDY) =  $\text{ase} * \text{sh}_{\min} * \text{fy}_{we} / \text{f}_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi = \text{af} * \text{pf} * \text{ff}_{e} / \text{f}_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

-----  
 $\phi_x = 0.00$

$\text{af} = 0.00$

b = 250.00

h = 3000.00

From EC8 A4.4.3(6),  $\text{pf} = 2\text{tf}/\text{bw} = 0.008128$

bw = 250.00

effective stress from (A.35),  $\text{ff}_{e} = 636.1644$

-----  
 $\phi_y = 0.00$

$\text{af} = 0.00$

b = 3000.00

h = 250.00

From EC8 A4.4.3(6),  $\text{pf} = 2\text{tf}/\text{bw} = 0.00067733$

bw = 3000.00

effective stress from (A.35),  $\text{ff}_{e} = 944.3987$

-----  
R = 40.00

Effective FRP thickness,  $\text{tf} = \text{NL} * \text{t} * \text{Cos}(b1) = 1.016$

$\text{fu}_{,f} = 1055.00$

$E_f = 64828.00$

$\text{u}_{,f} = 0.015$

$\text{ase}$  ((5.4d), TBDY) =  $(\text{ase1} * \text{A}_{col1} + \text{ase2} * \text{A}_{col2} + \text{ase3} * \text{A}_{web}) / \text{A}_{sec} = 0.00$

$\text{ase1} = 0.00$

$\text{sh}_1 = 150.00$

$\text{bo}_1 = 190.00$

$\text{ho}_1 = 540.00$

$\text{bi}_{2,1} = 655400.00$

$\text{ase2} = 0.00$

$\text{sh}_2 = 150.00$

$\text{bo}_2 = 190.00$

$\text{ho}_2 = 540.00$

$$bi2\_2 = 655400.00$$

ase3 = 0 (grid does not provide confinement)

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00069813$$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh,x = ps1,x + ps2,x + ps3,x = 0.00356047$$

$$ps1,x \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00083776$$

$$h1 = 600.00$$

$$As1 = Astir1 \cdot ns1 = 157.0796$$

No stirrups, ns1 = 2.00

$$ps2,x \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00083776$$

$$h2 = 600.00$$

$$As2 = Astir2 \cdot ns2 = 157.0796$$

No stirrups, ns2 = 2.00

$$ps3,x \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00188496$$

$$h3 = 1800.00$$

$$As3 = Astir3 \cdot ns3 = 0.00$$

No stirrups, ns3 = 2.00

$$psh,y = ps1,y + ps2,y + ps3,y = 0.00069813$$

$$ps1,y \text{ (column 1)} = (As1 \cdot h1 / s\_1) / Ac = 0.00034907$$

$$h1 = 250.00$$

$$As1 = Astir1 \cdot ns1 = 157.0796$$

No stirrups, ns1 = 2.00

$$ps2,y \text{ (column 2)} = (As2 \cdot h2 / s\_2) / Ac = 0.00034907$$

$$h2 = 250.00$$

$$As2 = Astir2 \cdot ns2 = 157.0796$$

No stirrups, ns2 = 2.00

$$ps3,y \text{ (web)} = (As3 \cdot h3 / s\_3) / Ac = 0.00$$

$$h3 = 250.00$$

$$As3 = Astir3 \cdot ns3 = 157.0796$$

No stirrups, ns3 = 0.00

$$Asec = 750000.00$$

$$s\_1 = 150.00$$

$$s\_2 = 150.00$$

$$s\_3 = 200.00$$

$$fywe = 500.00$$

$$fce = 16.00$$

From ((5.A5), TBDY), TBDY: cc = 0.00204062

$$c = \text{confinement factor} = 1.00406$$

$$y1 = 0.00120915$$

$$sh1 = 0.00467215$$

$$ft1 = 348.235$$

$$fy1 = 290.1959$$

$$su1 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/l_d = 0.31638566$$

$$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.03226667$$

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 290.1959$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00120915$$

$$sh2 = 0.00467215$$

$$ft2 = 348.235$$

$$fy2 = 290.1959$$

$$su2 = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/l_b,min = 0.31638566$$

$$su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08066667$ ,

For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$$y_v = 0.00120915$$

$$sh_v = 0.00467215$$

$$ft_v = 348.235$$

$$fy_v = 290.1959$$

$$suv = 0.00579712$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.31638566$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08066667$ ,

considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_v = fs = 290.1959$

with  $Es_v = Es = 200000.00$

$$1 = As_{l,ten}/(b*d)*(fs_1/fc) = 0.07029503$$

$$2 = As_{l,com}/(b*d)*(fs_2/fc) = 0.07029503$$

$$v = As_{l,mid}/(b*d)*(fs_v/fc) = 0.01510726$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = As_{l,ten}/(b*d)*(fs_1/fc) = 0.09344146$$

$$2 = As_{l,com}/(b*d)*(fs_2/fc) = 0.09344146$$

$$v = As_{l,mid}/(b*d)*(fs_v/fc) = 0.02008172$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.14318411$$

$$\mu_u = MR_c (4.14) = 3.0413E+009$$

$$u = su (4.1) = 2.2880917E-006$$

-----  
Calculation of ratio  $lb/ld$

-----  
Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2735554E-006$$

$$\mu = 2.8453E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$\alpha_{co} (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0035$$

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  $\phi_f = \alpha_f * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_{fx} = 0.00$$

$$\alpha_f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$\phi_{fy} = 0.00$$

$$\alpha_f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } p_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = N L * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha_{se1} = 0.00$$

$$sh_{,1} = 150.00$$

$$bo_{,1} = 190.00$$

$$ho_{,1} = 540.00$$

$$bi_{2,1} = 655400.00$$

$$\alpha_{se2} = 0.00$$

$$sh_{,2} = 150.00$$

$$bo_{,2} = 190.00$$

$$ho_{,2} = 540.00$$

$$bi_{2,2} = 655400.00$$

$$\alpha_{se3} = 0 \text{ (grid does not provide confinement)}$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$$

$$p_{s1,x} \text{ (column 1)} = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$p_{s2,x} \text{ (column 2)} = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{stir2} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$p_{s3,x} \text{ (web)} = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

h3 = 1800.00  
As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00

fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_d = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_b,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l\_d = 0.31638566

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.03226667$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07029503$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07029503$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

and confined core properties:

$$b = 190.00$$

$$d = 2927.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 16.06499$$

$$cc (5A.5, TBDY) = 0.00204062$$

$c$  = confinement factor = 1.00406

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09344146$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09344146$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.00$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.13770595$$

$$Mu = MRc (4.14) = 2.8453E+009$$

$$u = su (4.1) = 2.2735554E-006$$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$$lb = 300.00$$

$$ld = 948.2098$$

Calculation of  $lb,min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$db = 16.85714$$

Mean strength value of all re-bars:  $fy = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 2.24399$$

$$n = 28.00$$

Calculation of  $Mu2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.2880917E-006$$

$$Mu = 3.0413E+009$$

with full section properties:

$$b = 250.00$$

$$d = 2957.00$$

$$d' = 43.00$$

$$v = 0.00232618$$

$$N = 27514.027$$

$$fc = 16.00$$

$$co (5A.5, TBDY) = 0.002$$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0035$

The  $\text{Shear\_factor}$  is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0035$

$w_e$  ((5.4c), TBDY) =  $a_{se} \cdot s_{h,min} \cdot f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$

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)

$f_x = 0.00$

$a_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.008128$

$bw = 250.00$

effective stress from (A.35),  $f_{f,e} = 636.1644$

$f_y = 0.00$

$a_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00067733$

$bw = 3000.00$

effective stress from (A.35),  $f_{f,e} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL \cdot t \cdot \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web})/A_{sec} = 0.00$

$a_{se1} = 0.00$

$s_{h,1} = 150.00$

$b_{o,1} = 190.00$

$h_{o,1} = 540.00$

$b_{i2,1} = 655400.00$

$a_{se2} = 0.00$

$s_{h,2} = 150.00$

$b_{o,2} = 190.00$

$h_{o,2} = 540.00$

$b_{i2,2} = 655400.00$

$a_{se3} = 0$  (grid does not provide confinement)

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$

$p_{s1,x}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00083776$

$h_1 = 600.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,x}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00083776$

$h_2 = 600.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,x}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00188496$

$h_3 = 1800.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$

No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$

$p_{s1,y}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00034907$

$h_1 = 250.00$

$A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$p_{s2,y}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00034907$

$h_2 = 250.00$

$A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$

No stirrups,  $n_{s2} = 2.00$

$p_{s3,y}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00$

$h_3 = 250.00$

$A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$

No stirups, ns3 = 0.00

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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 = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07029503

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07029503

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.01510726

and confined core properties:

b = 190.00

d = 2927.00

d' = 13.00

fcc (5A.2, TBDY) = 16.06499

$$cc (5A.5, TBDY) = 0.00204062$$

$$c = \text{confinement factor} = 1.00406$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09344146$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09344146$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.02008172$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.14318411$$

$$Mu = MRc (4.14) = 3.0413E+009$$

$$u = su (4.1) = 2.2880917E-006$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Lap Length:  $l_b/l_d = 0.31638566$

$$l_b = 300.00$$

$$l_d = 948.2098$$

Calculation of  $l_b, \min$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
= 1

$$d_b = 16.85714$$

Mean strength value of all re-bars:  $f_y = 500.00$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.9920E+006$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 1.9920E+006$

From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r1} = V_n < 0.83*fc'^{0.5}*h*d$

-----  
NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$

$$Mu/V_u - l_w/2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$fc' = 16.00, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$Mu = 2.8012401E-010$$

$$V_u = 6.3108872E-029$$

$$Nu = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

$V_{s1}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

$V_{s2}$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

Vs3 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 1.5581E+006$$

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|), \text{ with:}$$

total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.016$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 2957.00$$

$$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$$

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

with  $f_u = 0.01$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.5943E+006$$

$$b_w = 250.00$$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 1.9920E+006$

$$\text{From (22.5.1.1) and 11.5.4.3, ACI 318-14: } V_{r2} = V_n < 0.83 * f_c'^{0.5} * h * d$$

-----  
NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw + f \* V\_f' where V\_f is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$

$$\mu_u / \nu_u - l_w / 2 = 0.00 \leq 0$$

= 1 (normal-weight concrete)

$$f_c' = 16.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$h = 250.00$$

$$d = 2400.00$$

$$l_w = 3000.00$$

$$\mu_u = 2.8012401E-010$$

$$\nu_u = 6.3108872E-029$$

$$N_u = 27514.027$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 854513.202$

$V_{s1} = 201061.93$  is calculated for pseudo-Column 1, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

Vs1 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s2} = 201061.93$  is calculated for pseudo-Column 2, with:

$$d = 480.00$$

$$A_v = 157079.633$$

$$s = 150.00$$

$$f_y = 400.00$$

Vs2 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_{s3} = 452389.342$  is calculated for web, with:

$$d = 1440.00$$

$$A_v = 157079.633$$

$$s = 200.00$$

$$f_y = 400.00$$

Vs3 has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 1.5581E+006$$

$f = 0.95$ , 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  $\theta$  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:  $\theta = b_1 + 90^\circ = 90.00$

$$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|), \text{ with:}$$

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  
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 = 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,  $\gamma = 0.85$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 16.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$

#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 500.00$

#####  
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 = 1.00406  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
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,  $V_a = 0.00$   
EDGE -B-  
Shear Force,  $V_b = 0.00$   
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:  $As_{,ten} = 2368.761$

-Compression:  $As_{,com} = 2368.761$

-Middle:  $As_{,mid} = 0.00$

(According to 10.7.2.3  $As_{,mid}$  is setted equal to zero)

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.14054053$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 118250.575$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.7738E+008$

$Mu_{1+} = 1.4516E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.7738E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.7738E+008$

$Mu_{2+} = 1.4516E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.7738E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 3.4223799E-005$

$M_u = 1.4516E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

$\phi_{co}$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.0035$

where (5.4c), TBDY) =  $\phi_u * \text{sh}_{,min} * f_{ywe}/f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$

where  $\phi_x = \phi_y = \phi_u * \text{pf} * f_{fe}/f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$\phi_x = 0.00$

$\phi_y = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $\text{pf} = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35),  $f_{fe} = 636.1644$

$\phi_y = 0.00$

$\phi_x = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $\text{pf} = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $f_{fe} = 944.3987$

$R = 40.00$   
 Effective FRP thickness,  $t_f = NL * t * \cos(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $ase \text{ ((5.4d), TBDY)} = (ase_1 * A_{col1} + ase_2 * A_{col2} + ase_3 * A_{web}) / A_{sec} = 0.00$   
 $ase_1 = 0.00$   
 $sh_1 = 150.00$   
 $bo_1 = 190.00$   
 $ho_1 = 540.00$   
 $bi_{2,1} = 655400.00$   
 $ase_2 = 0.00$   
 $sh_2 = 150.00$   
 $bo_2 = 190.00$   
 $ho_2 = 540.00$   
 $bi_{2,2} = 655400.00$   
 $ase_3 = 0$  (grid does not provide confinement)  
 $psh_{,min} = \text{Min}(psh_{,x}, psh_{,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $psh_{,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----

$psh_{,x} = ps_{1,x} + ps_{2,x} + ps_{3,x} = 0.00356047$   
 $ps_{1,x} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00083776$   
 $h_1 = 600.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,x} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00083776$   
 $h_2 = 600.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,x} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $As_3 = Astir_3 * ns_3 = 0.00$   
 No stirrups,  $ns_3 = 2.00$

-----

$psh_{,y} = ps_{1,y} + ps_{2,y} + ps_{3,y} = 0.00069813$   
 $ps_{1,y} \text{ (column 1)} = (As_1 * h_1 / s_1) / A_c = 0.00034907$   
 $h_1 = 250.00$   
 $As_1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $ps_{2,y} \text{ (column 2)} = (As_2 * h_2 / s_2) / A_c = 0.00034907$   
 $h_2 = 250.00$   
 $As_2 = Astir_2 * ns_2 = 157.0796$   
 No stirrups,  $ns_2 = 2.00$   
 $ps_{3,y} \text{ (web)} = (As_3 * h_3 / s_3) / A_c = 0.00$   
 $h_3 = 250.00$   
 $As_3 = Astir_3 * ns_3 = 157.0796$   
 No stirrups,  $ns_3 = 0.00$

-----

$A_{sec} = 750000.00$   
 $s_1 = 150.00$   
 $s_2 = 150.00$   
 $s_3 = 200.00$   
 $f_{ywe} = 500.00$   
 $f_{ce} = 16.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00204062$   
 $c = \text{confinement factor} = 1.00406$

$y_1 = 0.00120915$   
 $sh_1 = 0.00467215$   
 $ft_1 = 348.235$   
 $fy_1 = 290.1959$   
 $su_1 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o / l_{ou,min} = l_b / l_d = 0.31638566$   
 $su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.03226667$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08066667$ ,

For 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  $fs1 = fs = 290.1959$

with  $Es1 = Es = 200000.00$

$y2 = 0.00120915$

$sh2 = 0.00467215$

$ft2 = 348.235$

$fy2 = 290.1959$

$su2 = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 0.31638566$

$su2 = 0.4*esu2\_nominal$  ((5.5), TBDY) =  $0.03226667$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08066667$ ,

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  $fs2 = fs = 290.1959$

with  $Es2 = Es = 200000.00$

$yv = 0.00120915$

$shv = 0.00467215$

$ftv = 348.235$

$fyv = 290.1959$

$suv = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.31638566$

$suv = 0.4*esuv\_nominal$  ((5.5), TBDY) =  $0.03226667$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,

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  $fsv = fs = 290.1959$

with  $Esv = Es = 200000.00$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.06885062$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.06885062$

$v = Asl, mid / (b * d) * (fsv / fc) = 0.00$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$fcc$  (5A.2, TBDY) =  $16.06499$

$cc$  (5A.5, TBDY) =  $0.00204062$

$c =$  confinement factor =  $1.00406$

$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.08209659$

$2 = Asl, com / (b * d) * (fs2 / fc) = 0.08209659$

$v = Asl, mid / (b * d) * (fsv / fc) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < vs, y2$  - LHS eq.(4.5) is satisfied

---

$su$  (4.9) =  $0.18563201$

$Mu = MRc$  (4.14) =  $1.4516E+008$

$u = su$  (4.1) =  $3.4223799E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $I_{b,min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$d_b = 16.85714$

Mean strength value of all re-bars:  $f_y = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

Calculation of  $\mu_{1-}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 3.5153739E-005$

$\mu = 1.7738E+008$

with full section properties:

$b = 3000.00$

$d = 208.00$

$d' = 42.00$

$v = 0.00275581$

$N = 27514.027$

$f_c = 16.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.0035$

$\mu_{we}$  ((5.4c), TBDY) =  $\alpha \cdot \text{sh}_{,min} * f_{ywe} / f_{ce} + \text{Min}(f_x, f_y) = 0.00$

where  $f = \alpha * p_f * f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$f_x = 0.00$

$\alpha_f = 0.00$

$b = 250.00$

$h = 3000.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.008128$

$b_w = 250.00$

effective stress from (A.35),  $f_{fe} = 636.1644$

$f_y = 0.00$

$\alpha_f = 0.00$

$b = 3000.00$

$h = 250.00$

From EC8 A.4.4.3(6),  $p_f = 2t_f/b_w = 0.00067733$

$b_w = 3000.00$

effective stress from (A.35),  $f_{fe} = 944.3987$

$R = 40.00$

Effective FRP thickness,  $t_f = NL * t * \text{Cos}(b_1) = 1.016$

$f_{u,f} = 1055.00$

$E_f = 64828.00$

$u_{,f} = 0.015$

$\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{col1} + \alpha_{se2} * A_{col2} + \alpha_{se3} * A_{web}) / A_{sec} = 0.00$

$\alpha_{se1} = 0.00$

$sh_{,1} = 150.00$

$bo_{,1} = 190.00$

$ho_{,1} = 540.00$

$bi_{2,1} = 655400.00$

$\alpha_{se2} = 0.00$

$sh_{,2} = 150.00$

$bo_{,2} = 190.00$

$ho_{,2} = 540.00$

$bi_{2,2} = 655400.00$

ase3 = 0 (grid does not provide confinement)  
psh,min = Min(psh,x , psh,y) = 0.00069813  
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
psh,x = ps1,x+ps2,x+ps3,x = 0.00356047  
ps1,x (column 1) = (As1\*h1/s\_1)/Ac = 0.00083776  
h1 = 600.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,x (column 2) = (As2\*h2/s\_2)/Ac = 0.00083776  
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 = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00  
From ((5.A5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406  
y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_d = 0.31638566  
su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667  
From table 5A.1, TBDY: esu1\_nominal = 0.08066667,  
For 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 = 290.1959  
with Es1 = Es = 200000.00  
y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/l\_b,min = 0.31638566  
su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $es_{u2\_nominal} = 0.08066667$ ,

For calculation of  $es_{u2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 290.1959$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00120915$

$sh_v = 0.00467215$

$ft_v = 348.235$

$fy_v = 290.1959$

$s_{uv} = 0.00579712$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lo_{u,min} = lb/ld = 0.31638566$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.03226667$

From table 5A.1, TBDY:  $es_{uv\_nominal} = 0.08066667$ ,

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_v = fs = 290.1959$

with  $Es_v = Es = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.06885062$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.06885062$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.04675268$

and confined core properties:

$b = 2940.00$

$d = 178.00$

$d' = 12.00$

$f_{cc} (5A.2, TBDY) = 16.06499$

$cc (5A.5, TBDY) = 0.00204062$

$c = \text{confinement factor} = 1.00406$

1 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.08209659$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.08209659$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.20717489$

$\mu_u = MR_c (4.14) = 1.7738E+008$

$u = s_u (4.1) = 3.5153739E-005$

-----  
Calculation of ratio  $lb/ld$

-----  
Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$

$ld = 948.2098$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

$db = 16.85714$

Mean strength value of all re-bars:  $fy = 500.00$

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.24399$

$n = 28.00$

-----  
Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.4223799E-005$$

$$Mu = 1.4516E+008$$

with full section properties:

$$b = 3000.00$$

$$d = 208.00$$

$$d' = 42.00$$

$$v = 0.00275581$$

$$N = 27514.027$$

$$f_c = 16.00$$

$$\alpha (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0035$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.0035$$

$$\omega_e \text{ ((5.4c), TBDY) } = \alpha s_e * \text{sh}_{, \text{min}} * f_{ywe} / f_{ce} + \text{Min}(\phi_x, \phi_y) = 0.00$$

where  $\phi = \alpha f_p^* f_{fe} / f_{ce}$  is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

$$\phi_x = 0.00$$

$$\alpha f = 0.00$$

$$b = 250.00$$

$$h = 3000.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.008128$$

$$b_w = 250.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 636.1644$$

$$\phi_y = 0.00$$

$$\alpha f = 0.00$$

$$b = 3000.00$$

$$h = 250.00$$

$$\text{From EC8 A.4.4.3(6), } \phi_f = 2t_f / b_w = 0.00067733$$

$$b_w = 3000.00$$

$$\text{effective stress from (A.35), } f_{f,e} = 944.3987$$

$$R = 40.00$$

$$\text{Effective FRP thickness, } t_f = NL * t * \text{Cos}(b_1) = 1.016$$

$$f_{u,f} = 1055.00$$

$$E_f = 64828.00$$

$$u_{,f} = 0.015$$

$$\alpha s_e \text{ ((5.4d), TBDY) } = (\alpha s_{e1} * A_{col1} + \alpha s_{e2} * A_{col2} + \alpha s_{e3} * A_{web}) / A_{sec} = 0.00$$

$$\alpha s_{e1} = 0.00$$

$$\text{sh}_{,1} = 150.00$$

$$\text{bo}_{,1} = 190.00$$

$$\text{ho}_{,1} = 540.00$$

$$\text{bi}_{2,1} = 655400.00$$

$$\alpha s_{e2} = 0.00$$

$$\text{sh}_{,2} = 150.00$$

$$\text{bo}_{,2} = 190.00$$

$$\text{ho}_{,2} = 540.00$$

$$\text{bi}_{2,2} = 655400.00$$

$$\alpha s_{e3} = 0 \text{ (grid does not provide confinement)}$$

$$\text{psh}_{, \text{min}} = \text{Min}(\text{psh}_{,x}, \text{psh}_{,y}) = 0.00069813$$

Expression ((5.4d), TBDY) for  $\text{psh}_{, \text{min}}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\text{psh}_{,x} = \text{ps}_{1,x} + \text{ps}_{2,x} + \text{ps}_{3,x} = 0.00356047$$

$$\text{ps}_{1,x} \text{ (column 1) } = (A_{s1} * h_1 / s_1) / A_c = 0.00083776$$

$$h_1 = 600.00$$

$$A_{s1} = A_{\text{stir1}} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$\text{ps}_{2,x} \text{ (column 2) } = (A_{s2} * h_2 / s_2) / A_c = 0.00083776$$

$$h_2 = 600.00$$

$$A_{s2} = A_{\text{stir2}} * n_{s2} = 157.0796$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$\text{ps}_{3,x} \text{ (web) } = (A_{s3} * h_3 / s_3) / A_c = 0.00188496$$

$$h_3 = 1800.00$$

As3 = Astir3\*ns3 = 0.00  
No stirups, ns3 = 2.00

-----  
psh,y = ps1,y+ps2,y+ps3,y = 0.00069813  
ps1,y (column 1) = (As1\*h1/s\_1)/Ac = 0.00034907  
h1 = 250.00  
As1 = Astir1\*ns1 = 157.0796  
No stirups, ns1 = 2.00  
ps2,y (column 2) = (As2\*h2/s\_2)/Ac = 0.00034907  
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 = 150.00  
s\_2 = 150.00  
s\_3 = 200.00  
fywe = 500.00  
fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062  
c = confinement factor = 1.00406

y1 = 0.00120915  
sh1 = 0.00467215  
ft1 = 348.235  
fy1 = 290.1959  
su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915  
sh2 = 0.00467215  
ft2 = 348.235  
fy2 = 290.1959  
su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915  
shv = 0.00467215  
ftv = 348.235  
fyv = 290.1959  
suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY:  $esuv\_nominal = 0.08066667$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = f_s = 290.1959$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06885062$   
 $2 = A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06885062$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

and confined core properties:

$b = 2940.00$   
 $d = 178.00$   
 $d' = 12.00$   
 $f_{cc}$  (5A.2, TBDY) = 16.06499  
 $cc$  (5A.5, TBDY) = 0.00204062  
 $c =$  confinement factor = 1.00406  
 $1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.08209659$   
 $2 = A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08209659$   
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.00$

Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->  
 $su$  (4.9) = 0.18563201  
 $Mu = MR_c$  (4.14) = 1.4516E+008  
 $u = su$  (4.1) = 3.4223799E-005

-----  
 Calculation of ratio  $lb/ld$

-----  
 Lap Length:  $lb/ld = 0.31638566$

$lb = 300.00$   
 $ld = 948.2098$

Calculation of  $lb_{min}$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $= 1$

$db = 16.85714$   
 Mean strength value of all re-bars:  $f_y = 500.00$   
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.24399$   
 $n = 28.00$

-----  
 Calculation of  $Mu_2$ -

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 3.5153739E-005$   
 $Mu = 1.7738E+008$

-----  
 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  $cu$ :  $cu^* = shear\_factor \cdot Max(cu, cc) = 0.0035$

The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.0035$

$w_e ((5.4c), TBDY) = a_{se} \cdot s_{h,min} \cdot f_{ywe}/f_{ce} + \text{Min}(f_x, f_y) = 0.00$   
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)

$f_x = 0.00$   
 $a_f = 0.00$   
 $b = 250.00$   
 $h = 3000.00$   
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.008128$   
 $bw = 250.00$   
effective stress from (A.35),  $f_{f,e} = 636.1644$

$f_y = 0.00$   
 $a_f = 0.00$   
 $b = 3000.00$   
 $h = 250.00$   
From EC8 A.4.4.3(6),  $p_f = 2t_f/bw = 0.00067733$   
 $bw = 3000.00$   
effective stress from (A.35),  $f_{f,e} = 944.3987$

$R = 40.00$   
Effective FRP thickness,  $t_f = NL \cdot t \cdot \text{Cos}(b_1) = 1.016$   
 $f_{u,f} = 1055.00$   
 $E_f = 64828.00$   
 $u_{,f} = 0.015$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} \cdot A_{col1} + a_{se2} \cdot A_{col2} + a_{se3} \cdot A_{web})/A_{sec} = 0.00$   
 $a_{se1} = 0.00$   
 $s_{h,1} = 150.00$   
 $b_{o,1} = 190.00$   
 $h_{o,1} = 540.00$   
 $b_{i2,1} = 655400.00$   
 $a_{se2} = 0.00$   
 $s_{h,2} = 150.00$   
 $b_{o,2} = 190.00$   
 $h_{o,2} = 540.00$   
 $b_{i2,2} = 655400.00$   
 $a_{se3} = 0$  (grid does not provide confinement)  
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00069813$

Expression ((5.4d), TBDY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} = p_{s1,x} + p_{s2,x} + p_{s3,x} = 0.00356047$   
 $p_{s1,x}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00083776$   
 $h_1 = 600.00$   
 $A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$   
No stirrups,  $n_{s1} = 2.00$   
 $p_{s2,x}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00083776$   
 $h_2 = 600.00$   
 $A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$   
No stirrups,  $n_{s2} = 2.00$   
 $p_{s3,x}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00188496$   
 $h_3 = 1800.00$   
 $A_{s3} = A_{stir3} \cdot n_{s3} = 0.00$   
No stirrups,  $n_{s3} = 2.00$

$p_{sh,y} = p_{s1,y} + p_{s2,y} + p_{s3,y} = 0.00069813$   
 $p_{s1,y}$  (column 1) =  $(A_{s1} \cdot h_1/s_1)/A_c = 0.00034907$   
 $h_1 = 250.00$   
 $A_{s1} = A_{stir1} \cdot n_{s1} = 157.0796$   
No stirrups,  $n_{s1} = 2.00$   
 $p_{s2,y}$  (column 2) =  $(A_{s2} \cdot h_2/s_2)/A_c = 0.00034907$   
 $h_2 = 250.00$   
 $A_{s2} = A_{stir2} \cdot n_{s2} = 157.0796$   
No stirrups,  $n_{s2} = 2.00$   
 $p_{s3,y}$  (web) =  $(A_{s3} \cdot h_3/s_3)/A_c = 0.00$   
 $h_3 = 250.00$   
 $A_{s3} = A_{stir3} \cdot n_{s3} = 157.0796$   
No stirrups,  $n_{s3} = 0.00$

Asec = 750000.00

s\_1 = 150.00

s\_2 = 150.00

s\_3 = 200.00

fywe = 500.00

fce = 16.00

From ((5.A.5), TBDY), TBDY: cc = 0.00204062

c = confinement factor = 1.00406

y1 = 0.00120915

sh1 = 0.00467215

ft1 = 348.235

fy1 = 290.1959

su1 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu1\_nominal = 0.08066667,

For 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 = 290.1959

with Es1 = Es = 200000.00

y2 = 0.00120915

sh2 = 0.00467215

ft2 = 348.235

fy2 = 290.1959

su2 = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.31638566

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esu2\_nominal = 0.08066667,

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 = 290.1959

with Es2 = Es = 200000.00

yv = 0.00120915

shv = 0.00467215

ftv = 348.235

fyv = 290.1959

suv = 0.00579712

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.31638566

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.03226667

From table 5A.1, TBDY: esuv\_nominal = 0.08066667,

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  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 290.1959

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06885062

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06885062

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04675268

and confined core properties:

b = 2940.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 16.06499

cc (5A.5, TBDY) = 0.00204062

c = confinement factor = 1.00406

1 =  $Asl_{ten}/(b*d)*(fs1/fc) = 0.08209659$

2 =  $Asl_{com}/(b*d)*(fs2/fc) = 0.08209659$

v =  $Asl_{mid}/(b*d)*(fsv/fc) = 0.05574729$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

v < vs,y2 - LHS eq.(4.5) is satisfied

---

su (4.9) = 0.20717489

Mu = MRc (4.14) = 1.7738E+008

u = su (4.1) = 3.5153739E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

Lap Length: lb/l<sub>d</sub> = 0.31638566

lb = 300.00

l<sub>d</sub> = 948.2098

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 16.85714

Mean strength value of all re-bars: fy = 500.00

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 2.24399

n = 28.00

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 841398.394

-----  
Calculation of Shear Strength at edge 1, Vr1 = 841398.394

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 = 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 = 1.9099438E-011

Vu = 0.00

Nu = 27514.027

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 + Vs3 = 83775.804

Vs1 = 41887.902 is calculated for pseudo-Column 1, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs1 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs2 = 41887.902 is calculated for pseudo-Column 2, with:

d = 200.00

Av = 157079.633

s = 150.00

fy = 400.00

Vs2 has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

2(1-s/d) = 0.50

Vs3 = 0.00 is calculated for web, with:

$d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$   
 $V_{s3}$  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).  
 $\ln(11.3) \sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
 where  $\theta$  is the angle of the crack direction (see KANEPE).  
 This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $a_i$ ,  
 as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.  
 orientation 1:  $\theta = b_1 + 90^\circ = 90.00$   
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$ , with:  
 total thickness per orientation,  $t_{f1} = N_L * t / \text{NoDir} = 1.016$   
 $d_{fv} = d$  (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,  $V_{r2} = 841398.394$   
 From (22.5.1.1) and 11.5.4.3, ACI 318-14:  $V_{r2} = V_n < 0.83 * f_c'^{0.5} * h * d$

-----  
 NOTE: In expression (22.5.1.1) ' $V_w$ ' is replaced by ' $V_w + f * V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 From Table (11.5.4.6(d-e)), ACI 318-14:  $V_c = 653502.805$   
 $\mu_u / V_u - l_w / 2 = 0.00 \leq 0$   
 $= 1$  (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $h = 3000.00$   
 $d = 200.00$   
 $l_w = 250.00$   
 $\mu_u = 1.9099438E-011$   
 $V_u = 0.00$   
 $N_u = 27514.027$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} + V_{s3} = 83775.804$   
 $V_{s1} = 41887.902$  is calculated for pseudo-Column 1, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s1}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s2} = 41887.902$  is calculated for pseudo-Column 2, with:  
 $d = 200.00$   
 $A_v = 157079.633$   
 $s = 150.00$   
 $f_y = 400.00$   
 $V_{s2}$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.50$   
 $V_{s3} = 0.00$  is calculated for web, with:  
 $d = 200.00$   
 $A_v = 0.00$   
 $s = 200.00$   
 $f_y = 400.00$

$V_{s3}$  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).  
 $\ln(11.3) \sin + \cos$  is replaced with  $(\cot + \cot a)\sin a$  which is more a generalised expression,  
 where  $\theta$  is the angle of the crack direction (see KANEPE).

This later relation, considered as a function  $V_f(\theta)$ , is implemented for every different fiber orientation  $\theta_i$ , as well as for 2 crack directions,  $\theta = 45^\circ$  and  $\theta = -45^\circ$  to take into consideration the cyclic seismic loading.

orientation 1:  $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$ , with:

total thickness per orientation,  $t_{f1} = N_L * t / N_{oDir} = 1.016$

$d_{fv} = d$  (figure 11.2, ACI 440) = 208.00

$f_{fe}$  ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$ , from (11.6a), ACI 440

with  $f_u = 0.01$

From (11-11), ACI 440:  $V_s + V_f \leq 1.5943E+006$

$b_w = 3000.00$

-----  
End Of Calculation of Shear Capacity ratio for element: wall W1 of floor 1

At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (d)

Section Type: rcrws

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.85$

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

$\rho_n = 0.00069813$

-----  
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  $\rho_{s1} = A_{s1} * b_1 / s_1 = (A_{s1} * h_1 / s_1) / A_c = 0.00034907$

$h_1 = 250.00$

$s_1 = 150.00$

total area of hoops perpendicular to shear axis,  $A_{s1} = 157.0796$

(pseudo-col.2  $\rho_{s2} = A_{s2} * b_2 / s_2 = (A_{s2} * h_2 / s_2) / A_c = 0.00034907$

$h_2 = 250.00$

$s_2 = 150.00$

total area of hoops perpendicular to shear axis,  $A_{s2} = 157.0796$

(grid  $\rho_{s3} = A_{s3} * b_3 / s_3 = (A_{s3} * h_3 / s_3) / A_c = 0.00$

$h_3 = 250.00$

$s_3 = 200.00$

total area of hoops perpendicular to shear axis,  $A_{s3} = 0.00$

total section area,  $A_c = 750000.00$

-----  
Consequently:

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at  $135^\circ$ )

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

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

Bending Moment,  $M = 6.1924294E-011$   
Shear Force,  $V_2 = 6.3856629E-015$   
Shear Force,  $V_3 = 28549.607$   
Axial Force,  $F = -29388.501$   
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:  $As_{c,mid} = 1608.495$   
Mean Diameter of Tension Reinforcement,  $Db_L = 17.20$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = u = 0.01382101$   
 $u = y + p = 0.01626001$

- Calculation of  $y$  -

$y = (M_y * I_p) / (EI)_{Eff} = 0.00126001$  ((10-5), ASCE 41-17))  
 $M_y = 1.5087E+008$   
 $(EI)_{Eff} = 0.35 * E_c * I$  (table 10-5)  
 $E_c * I = 8.2106E+013$   
 $I_p = 0.5 * d = 0.5 * (0.8 * h) = 240.00$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 8.7651352E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 269.394$   
 $d = 208.00$   
 $y = 0.26118462$   
 $A = 0.01034472$   
 $B = 0.00628654$   
with  $pt = 0.00379609$   
 $pc = 0.00379609$   
 $pv = 0.00257772$   
 $N = 29388.501$   
 $b = 3000.00$   
 $" = 0.20192308$   
 $y_{comp} = 2.54444482E-005$   
with  $f_c^*$  (12.3, (ACI 440)) = 16.002  
 $f_c = 16.00$   
 $f_l = 0.17503396$   
 $b = 3000.00$   
 $h = 250.00$   
 $Ag = 750000.00$   
From (12.9), ACI 440:  $k_a = 0.00364754$

$$g = p_t + p_c + p_v = 0.0101699$$

$$r_c = 40.00$$

$$A_e/A_c = 0.52524587$$

$$\text{Effective FRP thickness, } t_f = N_L * t * \cos(b_1) = 1.016$$

$$\text{effective strain from (12.5) and (12.12), } e_{fe} = 0.004$$

$$f_u = 0.01$$

$$E_f = 64828.00$$

$$E_c = 21019.039$$

$$y = 0.2589268$$

$$A = 0.00999806$$

$$B = 0.00611172$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio  $l_b/l_d$

$$\text{Lap Length: } l_d/l_{d,\min} = 0.39548208$$

$$l_b = 300.00$$

$$l_d = 758.5679$$

Calculation of  $l$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$$= 1$$

$$d_b = 16.85714$$

$$\text{Mean strength value of all re-bars: } f_y = 400.00$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.24399$$

$$n = 28.00$$

- Calculation of  $p$  -

Considering wall controlled by flexure (shear control ratio  $\leq 1$ ),

from table 10-19:  $p = 0.015$

with:

- Condition i (shear wall and wall segments)

$$-(A_s - A_s') * f_y + P / (t_w * l_w * f_c') = -0.20908486$$

$$A_s = 0.00$$

$$A_s' = 6346.017$$

$$f_y = 400.00$$

$$P = 29388.501$$

$$t_w = 3000.00$$

$$l_w = 250.00$$

$$f_c = 16.00$$

-  $V / (t_w * l_w * f_c^{0.5}) = 2.5633503E-020$ , NOTE: units in lb & in

- Confined Boundary: No

Boundary hoops spacing exceed  $8d_b$  ( $s_1 > 8 * d_b$  or  $s_2 > 8 * d_b$ )

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:

$$V_{w1} = 83775.804$$

$$s_1 = 150.00$$

Boundary Element 2:

$$V_{w2} = 83775.804$$

$$s_2 = 150.00$$

Grid Shear Force,  $V_{w3} = 0.00$

Concrete Shear Force,  $V_c = 126390.829$

(The variables above have already been given in Shear control ratio calculation)

Mean diameter of all bars,  $d_b = 17.33333$

Design Shear Force,  $V = 6.3856629E-015$

End Of Calculation of Chord Rotation Capacity for element: wall W1 of floor 1

At local axis: 3

Integration Section: (d)

