

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

beam B1, Floor 1

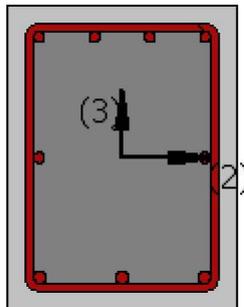
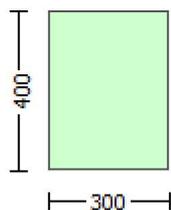
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$   
Section Height,  $H = 400.00$   
Section Width,  $W = 300.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 1850.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$   
No FRP Wrapping

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Stepwise Properties  
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EDGE -A-  
Bending Moment,  $M_a = -7.2037543E-011$   
Shear Force,  $V_a = -2.9102230E-014$   
EDGE -B-  
Bending Moment,  $M_b = 1.8189791E-011$   
Shear Force,  $V_b = 2.9102230E-014$   
BOTH EDGES  
Axial Force,  $F = -459.9979$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{s,t} = 603.1858$   
-Compression:  $A_{s,c} = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{s,ten} = 508.938$   
-Compression:  $A_{s,com} = 508.938$   
-Middle:  $A_{s,mid} = 508.938$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 14.66667$

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New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 171047.78$   
 $V_n$  ((22.5.1.1), ACI 318-14) = 171047.78  
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NOTE: In expression (22.5.1.1) 'V<sub>w</sub>' is replaced by 'V<sub>w</sub> + f<sub>v</sub>V<sub>f</sub>'  
where V<sub>f</sub> is the contribution of FRPs (11.3), ACI 440).  
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From Table (22.5.5.1), ACI 318-14:  $V_c = 76800.00$   
= 1 (normal-weight concrete)  
 $f'_c = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w \cdot d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u \cdot d / M_u < 1 = 0.00$   
 $M_u = 7.2037543E-011$   
 $V_u = 2.9102230E-014$   
From (11.5.4.8), ACI 318-14:  $V_s = 94247.78$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 150.00$   
 $V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17, 10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 318865.838$   
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End Of Calculation of Shear Capacity for element: beam B1 of floor 1  
At local axis: 2  
Integration Section: (a)  
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## Calculation No. 2

beam B1, Floor 1

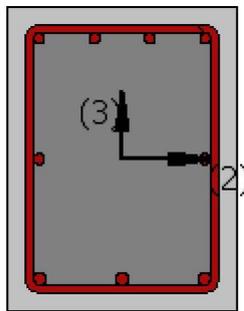
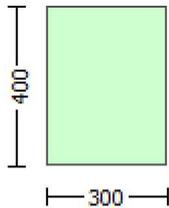
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

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Note: Especially for the calculation of moment strengths,

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

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

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Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

## Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 2740.264$

EDGE -B-

Shear Force,  $V_b = 2740.264$

BOTH EDGES

Axial Force,  $F = -189.411$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 603.1858$

-Compression:  $As_c = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 603.1858$

-Compression:  $As_{c,com} = 615.7522$

-Middle:  $As_{l,mid} = 307.8761$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.39580698$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n / 2 = 112670.646$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0175E+008$

$Mu_{1+} = 9.9812E+007$ , 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

$Mu_{1-} = 1.0175E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0162E+008$

$Mu_{2+} = 9.9934E+007$ , 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

$Mu_{2-} = 1.0162E+008$ , 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

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 2740.264$ , is the shear force acting at edge 1 for the the static loading combination

$V_2 = 2740.264$ , is the shear force acting at edge 2 for the the static loading combination

Calculation of  $Mu_{1+}$

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

$u = 1.7580246E-005$

$Mu = 9.9812E+007$

with full section properties:

$b = 300.00$

$d = 357.00$

$d' = 42.00$

$v = 5.3592212E-005$

$N = 189.411$

$f_c = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$

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

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e (5.4c) = 0.00259035$

$ase ((5.4d), TBDY) = 0.15672608$

$bo = 240.00$

$ho = 340.00$

$bi2 = 346400.00$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$$

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)

$$psh,x (5.4d) = 0.00349066$$

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 300.00$$

$$psh,y (5.4d) = 0.00261799$$

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

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

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

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

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs/1.2$ , 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.

$$\text{with } fs1 = fs = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

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

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

with  $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.06639156$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.06777471$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$c$  = confinement factor = 1.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09060316$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09249072$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04624536$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

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$$s_u (4.9) = 0.18421297$$

$$M_u = M_{Rc} (4.14) = 9.9812E+007$$

$$u = s_u (4.1) = 1.7580246E-005$$

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Calculation of ratio  $l_b/d$

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Inadequate Lap Length with  $l_b/d = 0.30$   
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Calculation of  $M_{u1}$ -  
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Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7569691E-005$$

$$M_u = 1.0175E+008$$

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with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00553582$$

$$\omega_e (5.4c) = 0.00259035$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 300.00$$

$$p_{sh,y} (5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 400.00$$

$s = 150.00$   
 $fy_{we} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 466.8167$   
 $fy_1 = 389.0139$   
 $su_1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 0.30$   
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = fs = 389.0139$   
 with  $Es_1 = Es = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.30$   
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = fs = 389.0139$   
 with  $Es_2 = Es = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 0.30$   
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 389.0139$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.0675854$   
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.06620611$   
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.0337927$   
 and confined core properties:  
 $b = 240.00$   
 $d = 328.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$   
 $cc \text{ (5A.5, TBDY)} = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.09220874$   
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.09032693$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04610437$$

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

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

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$$s_u(4.9) = 0.18600297$$

$$\mu_u = M_{Rc}(4.14) = 1.0175E+008$$

$$u = s_u(4.1) = 1.7569691E-005$$

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Calculation of ratio  $l_b/l_d$

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Inadequate Lap Length with  $l_b/l_d = 0.30$   
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Calculation of  $\mu_{u2+}$   
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Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7539903E-005$$

$$\mu_u = 9.9934E+007$$

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with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}(5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00261799$$

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)

$$p_{sh, x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh, y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

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

Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06620611

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.0675854

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.0337927

and confined core properties:

b = 240.00

d = 328.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09032693

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09220874

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04610437

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.18462058

Mu = MRc (4.14) = 9.9934E+007

u = su (4.1) = 1.7539903E-005

-----  
Calculation of ratio lb/d  
-----

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_2$ -

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

$$\mu = 1.7610316E-005$$

$$\mu = 1.0162E+008$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 5.3592212E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_2_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_2_{nominal} = 0.08$ ,

For calculation of  $esu_2_{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

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

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

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.06777471$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.06639156$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09249072$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09060316$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.04624536$$

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

--->

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

--->

$$su (4.9) = 0.18560594$$

$$\mu = MR_c (4.14) = 1.0162E+008$$

$$u = su (4.1) = 1.7610316E-005$$

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

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

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 284660.584$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 284660.584$

$$V_{r1} = V_n ((22.5.1.1), ACI 318-14)$$

-----  
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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
 $= 1$  (normal-weight concrete)  
 $f'_c = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/M_u < 1 = 1.00$   
 $M_u = 69262.055$   
 $V_u = 2740.264$   
From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

Calculation of Shear Strength at edge 2,  $V_{r2} = 284660.584$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
 $= 1$  (normal-weight concrete)  
 $f'_c = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/M_u < 1 = 1.00$   
 $M_u = 69262.055$   
 $V_u = 2740.264$   
From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength,  $f_s = 1.25*f_{sm} = 694.45$   
#####

Section Height, H = 400.00  
Section Width, W = 300.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 1850.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min}$  = 0.30  
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a$  = -8.6414578E-021  
EDGE -B-  
Shear Force,  $V_b$  = 8.6414578E-021  
BOTH EDGES  
Axial Force, F = -189.411  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st}$  = 603.1858  
-Compression:  $A_{sc}$  = 923.6282  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten}$  = 508.938  
-Compression:  $A_{st,com}$  = 508.938  
-Middle:  $A_{st,mid}$  = 508.938  
-----  
-----

Calculation of Shear Capacity ratio,  $V_e/V_r$  = 0.37228966  
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 71835.924$   
with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 6.6448E+007$   
 $M_{u1+} = 6.6448E+007$ , 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  
 $M_{u1-} = 6.6448E+007$ , 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  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 6.6448E+007$   
 $M_{u2+} = 6.6448E+007$ , 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  
 $M_{u2-} = 6.6448E+007$ , 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  
and  
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$   
with  
 $V_1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination  
 $V_2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 2.4749691E-005$   
 $M_u = 6.6448E+007$   
-----

with full section properties:  
 $b = 400.00$   
 $d = 258.00$   
 $d' = 42.00$

v = 5.5617499E-005

N = 189.411

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$

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

From (5.4b), TBDY:  $cu = 0.00553582$

we (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x, psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

-----  
psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

-----  
s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

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

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

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

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value  $\text{fsy1} = \text{fs1}/1.2$ , 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  $\text{fs1} = \text{fs} = 389.0139$

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

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

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

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

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value  $\text{fsy2} = \text{fs2}/1.2$ , 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  $\text{fs2} = \text{fs} = 389.0139$

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

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07739312

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07739312

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07739312

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

-----  
Calculation of ratio lb/d

-----  
Inadequate Lap Length with lb/d = 0.30  
-----  
-----

-----  
Calculation of Mu1-  
-----  
-----

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

u = 2.4749691E-005

Mu = 6.6448E+007  
-----

with full section properties:

b = 400.00

d = 258.00

d' = 42.00

v = 5.5617499E-005

N = 189.411

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00553582

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

From (5.4b), TBDY: cu = 0.00553582

we (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 300.00

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

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

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05813483$$
$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05813483$$
$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.19817337$$

$$\mu_u = M_{Rc} (4.14) = 6.6448E+007$$

$$u = s_u (4.1) = 2.4749691E-005$$

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

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

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

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

$$u = 2.4749691E-005$$

$$\mu_u = 6.6448E+007$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e (5.4c) = 0.00259035$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} (5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = fs = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$su_v = 0.00512$$

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

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } fs_v = fs = 389.0139$$

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

$$1 = As_{l,ten}/(b*d) * (fs_1/f_c) = 0.05813483$$

$$2 = As_{l,com}/(b*d) * (fs_2/f_c) = 0.05813483$$

$$v = As_{l,mid}/(b*d) * (fs_v/f_c) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = As_{l,ten}/(b*d) * (fs_1/f_c) = 0.07739312$$

$$2 = As_{l,com}/(b*d) * (fs_2/f_c) = 0.07739312$$

$$v = As_{l,mid}/(b*d) * (fs_v/f_c) = 0.07739312$$

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

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

--->  
 $s_u(4.9) = 0.19817337$   
 $\mu_u = M_{Rc}(4.14) = 6.6448E+007$   
 $u = s_u(4.1) = 2.4749691E-005$

-----  
Calculation of ratio  $I_b/I_d$

-----  
Inadequate Lap Length with  $I_b/I_d = 0.30$

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

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

$u = 2.4749691E-005$   
 $\mu_u = 6.6448E+007$

-----  
with full section properties:

$b = 400.00$   
 $d = 258.00$   
 $d' = 42.00$   
 $v = 5.5617499E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $c_o(5A.5, TBDY) = 0.002$   
Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $c_u = 0.00553582$   
 $w_e(5.4c) = 0.00259035$   
 $a_{se}((5.4d), TBDY) = 0.15672608$   
 $b_o = 240.00$   
 $h_o = 340.00$   
 $b_{i2} = 346400.00$   
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

-----  
 $p_{sh,x}(5.4d) = 0.00349066$   
 $A_{sh} = A_{stir} * n_s = 78.53982$   
No stirrups,  $n_s = 2.00$   
 $b_k = 300.00$

-----  
 $p_{sh,y}(5.4d) = 0.00261799$   
 $A_{sh} = A_{stir} * n_s = 78.53982$   
No stirrups,  $n_s = 2.00$   
 $b_k = 400.00$

-----  
 $s = 150.00$   
 $f_{ywe} = 694.45$   
 $f_{ce} = 33.00$

From ((5A5), TBDY), TBDY:  $c_c = 0.002$   
 $c = \text{confinement factor} = 1.00$

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

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

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

$$s_u1 = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s1\_nominal} = 0.08,$$

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

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

$$\text{with } f_{s1} = f_s = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$s_u2 = 0.00512$$

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

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

$$\text{Shear\_factor} = 1.00$$

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s2\_nominal} = 0.08,$$

For calculation of  $e_{s2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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.

$$\text{with } f_{s2} = f_s = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{u,v} = 0.00512$$

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

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

$$\text{Shear\_factor} = 1.00$$

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

$$s_{u,v} = 0.4 * e_{s_{u,v}\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s_{u,v}\_nominal} = 0.08,$$

considering characteristic value  $f_{s_{y,v}} = f_{s_{v}}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{s_{u,v}\_nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered

characteristic value  $f_{s_{y,v}} = f_{s_{v}}/1.2$ , from table 5.1, TBDY.

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

$$\text{with } f_{s_{v}} = f_s = 389.0139$$

$$\text{with } E_{s_{v}} = E_s = 200000.00$$

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.05813483$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.05813483$$

$$v = A_{s1,mid}/(b*d) * (f_{s_{v}}/f_c) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.07739312$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.07739312$$

$$v = A_{s1,mid}/(b*d) * (f_{s_{v}}/f_c) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.19817337$$

$$\text{Mu} = \text{MRc} (4.14) = 6.6448\text{E}+007$$

$$u = s_u (4.1) = 2.4749691\text{E}-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

-----  
-----  
-----  
-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 192957.075$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 192957.075$   
 $V_{r1} = V_n$  ((22.5.1.1), ACI 318-14)

-----  
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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/\mu < 1 = 0.00$   
 $\mu = 3.4215184E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

-----  
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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/\mu < 1 = 0.00$   
 $\mu = 3.4215797E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

-----  
End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1  
At local axis: 2  
Integration Section: (a)  
Section Type: rcars

## Constant Properties

Knowledge Factor,  $\phi = 0.90$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$

No FRP Wrapping

## Stepwise Properties

Bending Moment,  $M = 4.3814E+006$

Shear Force,  $V_2 = -2.9102230E-014$

Shear Force,  $V_3 = -2011.333$

Axial Force,  $F = -459.9979$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 603.1858$

-Compression:  $A_{sc} = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 603.1858$

-Compression:  $A_{sc,com} = 615.7522$

-Middle:  $A_{st,mid} = 307.8761$

Mean Diameter of Tension Reinforcement,  $D_bL = 16.00$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.00895818$

$u = y + p = 0.00895818$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00395818$  ((4.29), Biskinis Phd))

$M_y = 7.0646E+007$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2178.341

From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 1.2960E+013$

Calculation of Yielding Moment  $M_y$

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

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

$y_{ten} = 5.8345902E-006$

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

$d = 357.00$

$y = 0.25295531$

$A = 0.01426977$

$B = 0.00792861$

with  $p_t = 0.00563199$

$p_c = 0.00574932$

pv = 0.00287466  
N = 459.9979  
b = 300.00  
" = 0.11764706  
y\_comp = 2.4377991E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.25279326  
A = 0.01424621  
B = 0.00791481  
with Es = 200000.00

-----  
-----  
Calculation of ratio lb/d

-----  
Inadequate Lap Length with lb/d = 0.30

-----  
- Calculation of p -

-----  
From table 10-7: p = 0.005

with:

- Condition iv occurred

Beam controlled by inadequate embedment into beam-column joint:  
(lb/d < 1 and With Lapping in the Vicinity of the End Regions

- Condition i occurred

Beam controlled by flexure: Vp/Vo <= 1  
shear control ratio Vp/Vo = 0.39580698

- Transverse Reinforcement: NC

- Stirrup Spacing > d/3

- Low ductility demand, / y < 2 (table 10-6, ASCE 41-17)  
= 4.5852551E-005

- Stirrup Spacing <= d/2

d = 357.00

s = 150.00

- Strength provided by hoops Vs < 3/4\*design Shear

Vs = 186169.943, already given in calculation of shear control ratio  
design Shear = 2011.333

- ( - ')/ bal = -0.17558466

= Aslt/(bw\*d) = 0.00563199

Tension Reinf Area: Aslt = 603.1858

' = Asc/(bw\*d) = 0.00862398

Compression Reinf Area: Asc = 923.6282

From (B-1), ACI 318-11: bal = 0.01704017

fc = 33.00

fy = 555.56

From 10.2.7.3, ACI 318-11: 1 = 0.65

From fig R10.3.3, ACI 318-11 (Ence 454, too): 87000/(87000+ fy) = cb/dt = 0.003/(0.003+ y) = 0.51922877  
y = 0.0027778

- V/(bw\*d\*fc^0.5) = 0.03936958, NOTE: units in lb & in

bw = 300.00

-----  
End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (a)

## Calculation No. 3

beam B1, Floor 1

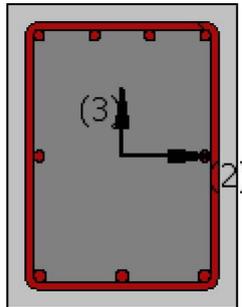
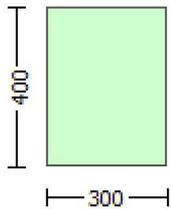
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 4.3814E+006$

Shear Force,  $V_a = -2011.333$   
EDGE -B-  
Bending Moment,  $M_b = 4.4091E+006$   
Shear Force,  $V_b = 7491.862$   
BOTH EDGES  
Axial Force,  $F = -459.9979$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 603.1858$   
-Compression:  $A_{sc} = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 603.1858$   
-Compression:  $A_{sc,com} = 615.7522$   
-Middle:  $A_{st,mid} = 307.8761$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.00$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 245857.952$   
 $V_n$  ((22.5.1.1), ACI 318-14) = 245857.952

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 (22.5.5.1), ACI 318-14:  $V_c = 78306.344$   
= 1 (normal-weight concrete)  
 $f_c' = 25.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s / (b_w \cdot d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u \cdot d / M_u < 1 = 0.14690078$   
 $M_u = 4.3814E+006$   
 $V_u = 2011.333$   
From (11.5.4.8), ACI 318-14:  $V_s = 167551.608$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 318865.838$

End Of Calculation of Shear Capacity for element: beam B1 of floor 1  
At local axis: 3  
Integration Section: (a)

## Calculation No. 4

beam B1, Floor 1

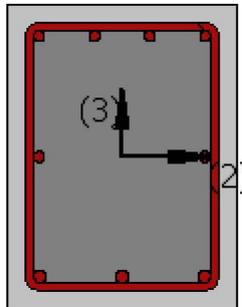
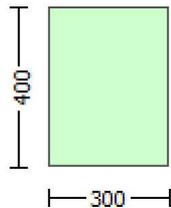
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

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

#####

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 2740.264$

EDGE -B-

Shear Force,  $V_b = 2740.264$   
BOTH EDGES  
Axial Force,  $F = -189.411$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 603.1858$   
-Compression:  $As_c = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 603.1858$   
-Compression:  $As_{c,com} = 615.7522$   
-Middle:  $As_{c,mid} = 307.8761$

-----  
-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 0.39580698$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 112670.646$   
with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.0175E+008$   
 $M_{u1+} = 9.9812E+007$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $M_{u1-} = 1.0175E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.0162E+008$   
 $M_{u2+} = 9.9934E+007$ , 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  
 $M_{u2-} = 1.0162E+008$ , 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  
and  
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$   
with  
 $V_1 = 2740.264$ , is the shear force acting at edge 1 for the the static loading combination  
 $V_2 = 2740.264$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 1.7580246E-005$   
 $M_u = 9.9812E+007$

-----  
with full section properties:

$b = 300.00$   
 $d = 357.00$   
 $d' = 42.00$   
 $v = 5.3592212E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $\phi_c$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_c = 0.00553582$   
 $w_e$  (5.4c) = 0.00259035  
 $a_{se}$  ((5.4d), TBDY) = 0.15672608  
 $b_o = 240.00$   
 $h_o = 340.00$   
 $b_{i2} = 346400.00$   
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$   
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)

-----  
 $p_{sh,x}$  (5.4d) = 0.00349066  
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$   
No stirrups,  $n_s = 2.00$   
 $b_k = 300.00$

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

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

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06639156

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06777471

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.03388736

and confined core properties:

b = 240.00  
d = 327.00  
d' = 12.00

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09060316$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09249072$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04624536$$

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

--->

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

--->

$$s_u (4.9) = 0.18421297$$

$$\mu_u = M_{Rc} (4.14) = 9.9812E+007$$

$$u = s_u (4.1) = 1.7580246E-005$$

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

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

-----  
Calculation of  $\mu_{u1}$ -  
-----

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

$$u = 1.7569691E-005$$

$$\mu_u = 1.0175E+008$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e (5.4c) = 0.00259035$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} (5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

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

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.0675854$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06620611$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.0337927$$

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09220874$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09032693$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04610437$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.18600297$$

$$Mu = MRc (4.14) = 1.0175E+008$$

$$u = s_u(4.1) = 1.7569691E-005$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_{2+}$

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

$$u = 1.7539903E-005$$

$$\mu = 9.9934E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TB DY: } \mu = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}((5.4d), \text{TB DY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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

$$p_{sh,x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal}((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_1_{nominal} = 0.08,$$

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 389.0139$$

with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fs_2 = fs_2/1.2$ , 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  $fs_2 = fs = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = fs = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.06620611$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.0675854$   
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.0337927$   
 and confined core properties:  
 $b = 240.00$   
 $d = 328.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09032693$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09220874$   
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.04610437$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18462058$   
 $Mu = MRc (4.14) = 9.9934E+007$   
 $u = su (4.1) = 1.7539903E-005$

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

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

Calculation of  $Mu_2$ -  
 -----  
 -----  
 -----

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

$$u = 1.7610316E-005$$

$$Mu = 1.0162E+008$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 5.3592212E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 466.8167$$

$$f_{y1} = 389.0139$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of  $esu1_{nominal}$  and  $y_1, sh_1, f_{t1}, f_{y1}$ , it is considered characteristic value  $f_{s1} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 466.8167$$

$$f_{y2} = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal}((5.5), TBDY) = 0.032$$

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

For calculation of  $esu2_{nominal}$  and  $y_2, sh_2, f_{t2}, f_{y2}$ , it is considered

characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

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

with  $f_{s2} = f_s = 389.0139$

with  $E_{s2} = E_s = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$suv = 0.00512$

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

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

Shear\_factor = 1.00

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

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

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

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

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , 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  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06777471$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06639156$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03388736$

and confined core properties:

b = 240.00

d = 327.00

d' = 12.00

f<sub>cc</sub> (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09249072$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09060316$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04624536$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

---

su (4.9) = 0.18560594

Mu = MRc (4.14) = 1.0162E+008

u = su (4.1) = 1.7610316E-005

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

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

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 284660.584$   
-----

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 284660.584$

$V_{r1} = V_n ((22.5.1.1), ACI 318-14)$   
-----

NOTE: In expression (22.5.1.1) 'V<sub>w</sub>' is replaced by 'V<sub>w</sub>+ f\*V<sub>f</sub>'  
where V<sub>f</sub> is the contribution of FRPs (11.3), ACI 440).  
-----

From Table (22.5.5.1), ACI 318-14:  $V_c = 98490.641$

= 1 (normal-weight concrete)

$f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$p_w = A_s/(b_w \cdot d) = 0.00628319$

$A_s$  (tension reinf.) = 603.1858

$b_w = 300.00$

d = 320.00

$V_u \cdot d / \text{Mu} < 1 = 1.00$

Mu = 69262.055

Vu = 2740.264

From (11.5.4.8), ACI 318-14: Vs = 186169.943

Av = 157079.633

fy = 555.56

s = 150.00

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

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 366348.956

Calculation of Shear Strength at edge 2, Vr2 = 284660.584

Vr2 = Vn ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14: Vc = 98490.641

= 1 (normal-weight concrete)

fc' = 33.00, but  $fc'^{0.5} <= 8.3$  MPa (22.5.3.1, ACI 318-14)

pw = As/(bw\*d) = 0.00628319

As (tension reinf.) = 603.1858

bw = 300.00

d = 320.00

Vu\*d/Mu < 1 = 1.00

Mu = 69262.055

Vu = 2740.264

From (11.5.4.8), ACI 318-14: Vs = 186169.943

Av = 157079.633

fy = 555.56

s = 150.00

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

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 366348.956

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcars

Constant Properties

Knowledge Factor, = 0.90

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

Consequently:

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

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

New material: Steel Strength, fs = 1.25\*fsm = 694.45

#####

Section Height, H = 400.00

Section Width, W = 300.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.00

Element Length, L = 1850.00

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -8.6414578E-021$   
EDGE -B-  
Shear Force,  $V_b = 8.6414578E-021$   
BOTH EDGES  
Axial Force,  $F = -189.411$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 603.1858$   
-Compression:  $As_c = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 508.938$   
-Compression:  $As_{c,com} = 508.938$   
-Middle:  $As_{c,mid} = 508.938$

-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.37228966$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 71835.924$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 6.6448E+007$   
 $Mu_{1+} = 6.6448E+007$ , 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  
 $Mu_{1-} = 6.6448E+007$ , 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  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 6.6448E+007$   
 $Mu_{2+} = 6.6448E+007$ , 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  
 $Mu_{2-} = 6.6448E+007$ , 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  
and  
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$   
with  
 $V_1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination  
 $V_2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 2.4749691E-005$   
 $M_u = 6.6448E+007$

-----  
with full section properties:

$b = 400.00$   
 $d = 258.00$   
 $d' = 42.00$   
 $v = 5.5617499E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $\phi_o$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_o) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.00553582$   
 $\phi_w$  (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

For calculation of  $e_{sv\_nominal}$  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.

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

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

1 =  $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05813483$

2 =  $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05813483$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05813483$

and confined core properties:

$b = 340.00$

$d = 228.00$

$d' = 12.00$

$f_{cc}$  (5A.2, TBDY) = 33.00

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

$c$  = confinement factor = 1.00

1 =  $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.07739312$

2 =  $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07739312$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07739312$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.19817337

$Mu = MRc$  (4.14) = 6.6448E+007

$u = su$  (4.1) = 2.4749691E-005

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

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

-----  
Calculation of  $Mu_1$ -  
-----  
-----

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

$u = 2.4749691E-005$

$Mu = 6.6448E+007$   
-----

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 5.5617499E-005$

$N = 189.411$

$f_c = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00553582$

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

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$ase$  ((5.4d), TBDY) = 0.15672608

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.00261799$

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)

-----  
 $psh_x$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$bk = 300.00$   
-----

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

-----  
s = 150.00  
fywe = 694.45  
fce = 33.00  
From ((5.A.5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

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

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00  
d = 228.00  
d' = 12.00  
fcc (5A.2, TBDY) = 33.00

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

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07739312$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.07739312$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07739312$$

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

--->

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

--->

$$su \text{ (4.9)} = 0.19817337$$

$$Mu = MRc \text{ (4.14)} = 6.6448E+007$$

$$u = su \text{ (4.1)} = 2.4749691E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu_{2+}$

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

$$u = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$ase \text{ ((5.4d), TBDY)} = 0.15672608$$

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$$

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)

$$psh,x \text{ (5.4d)} = 0.00349066$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 300.00$$

$$psh,y \text{ (5.4d)} = 0.00261799$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$f_{y1} = 389.0139$   
 $s_{u1} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{u1} = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{s1\_nominal} = 0.08$ ,  
 For calculation of  $e_{s1\_nominal}$  and  $y_1, sh_1, ft_1, f_{y1}$ , it is considered  
 characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s1} = f_s = 389.0139$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $f_{y2} = 389.0139$   
 $s_{u2} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $s_{u2} = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{s2\_nominal} = 0.08$ ,  
 For calculation of  $e_{s2\_nominal}$  and  $y_2, sh_2, ft_2, f_{y2}$ , it is considered  
 characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = f_s = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $f_{yv} = 389.0139$   
 $s_{uv} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $y_v, sh_v, ft_v, f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = f_s = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05813483$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05813483$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05813483$   
 and confined core properties:  
 $b = 340.00$   
 $d = 228.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $s_u (4.9) = 0.19817337$   
 $M_u = M_{Rc} (4.14) = 6.6448E+007$   
 $u = s_u (4.1) = 2.4749691E-005$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_2$

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

$$\mu = 2.4749691E-005$$

$$\mu_2 = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

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

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

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fs_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_1 = fs = 389.0139$$

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

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07739312

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07739312

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07739312

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30  
-----  
-----  
-----

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 192957.075  
-----

-----  
Calculation of Shear Strength at edge 1, Vr1 = 192957.075

Vr1 = Vn ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/M_u < 1 = 0.00$   
 $M_u = 3.4215184E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/M_u < 1 = 0.00$   
 $M_u = 3.4215797E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1  
At local axis: 3

Integration Section: (a)  
Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Section Height,  $H = 400.00$   
Section Width,  $W = 300.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 1850.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -7.2037543E-011$   
Shear Force,  $V_2 = -2.9102230E-014$   
Shear Force,  $V_3 = -2011.333$   
Axial Force,  $F = -459.9979$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 603.1858$   
-Compression:  $A_{sc} = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 508.938$   
-Compression:  $A_{sc,com} = 508.938$   
-Middle:  $A_{st,mid} = 508.938$   
Mean Diameter of Tension Reinforcement,  $D_bL = 14.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.00706586$   
 $u = y + p = 0.00706586$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00206586$  ((4.29), Biskinis Phd))  
 $M_y = 4.8843E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 925.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 7.2898E+012$

#### Calculation of Yielding Moment $M_y$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 8.1950237E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 311.2112$   
 $d = 258.00$   
 $y = 0.26403826$   
 $A = 0.01480903$   
 $B = 0.0086159$   
with  $p_t = 0.00493157$   
 $p_c = 0.00493157$   
 $p_v = 0.00493157$   
 $N = 459.9979$   
 $b = 400.00$   
 $" = 0.1627907$   
 $y_{comp} = 3.2314820E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.26388224$

A = 0.01478458  
B = 0.00860158  
with Es = 200000.00

-----  
-----  
Calculation of ratio  $l_b/d$

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

-----  
- Calculation of  $\rho$  -

-----  
From table 10-7:  $\rho = 0.005$

with:

- Condition iv occurred

Beam controlled by inadequate embedment into beam-column joint:  
( $l_b/d < 1$  and With Lapping in the Vicinity of the End Regions

- Condition i occurred

Beam controlled by flexure:  $V_p/V_o \leq 1$

shear control ratio  $V_p/V_o = 0.37228966$

- Transverse Reinforcement: NC

- Stirrup Spacing  $> d/3$

- Low ductility demand,  $\lambda / y < 2$  (table 10-6, ASCE 41-17)

= -4.0323671E-022

- Stirrup Spacing  $> d/2$

d = 258.00

s = 150.00

- Strength provided by hoops  $V_s < 3/4$ \*design Shear

$V_s = 139627.457$ , already given in calculation of shear control ratio

design Shear = 2.9102230E-014

- ( $\rho - \rho'$ )/ bal = -0.18222013

=  $A_{st}/(b_w*d) = 0.00584482$

Tension Reinf Area:  $A_{st} = 603.1858$

$\rho' = A_{sc}/(b_w*d) = 0.00894989$

Compression Reinf Area:  $A_{sc} = 923.6282$

From (B-1), ACI 318-11: bal = 0.01704017

$f_c = 33.00$

$f_y = 555.56$

From 10.2.7.3, ACI 318-11:  $\lambda = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too):  $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \lambda) = 0.51922877$

$y = 0.0027778$

-  $V/(b_w*d*f_c^{0.5}) = 5.9117060E-019$ , NOTE: units in lb & in

$b_w = 400.00$

-----  
End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (a)

-----  
**Calculation No. 5**

beam B1, Floor 1

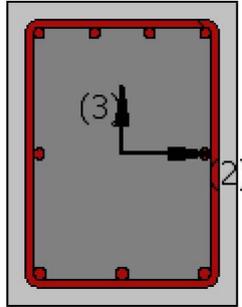
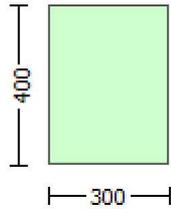
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -7.2037543E-011$

Shear Force,  $V_a = -2.9102230E-014$

EDGE -B-

Bending Moment,  $M_b = 1.8189791E-011$

Shear Force,  $V_b = 2.9102230E-014$

BOTH EDGES

Axial Force,  $F = -459.9979$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 615.7522$   
-Compression:  $As_c = 911.0619$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{,ten} = 508.938$   
-Compression:  $As_{,com} = 508.938$   
-Middle:  $As_{,mid} = 508.938$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 14.66667$

-----  
-----  
New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 171047.78$   
 $V_n$  ((22.5.1.1), ACI 318-14) = 171047.78

-----  
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 (22.5.5.1), ACI 318-14:  $V_c = 76800.00$   
= 1 (normal-weight concrete)  
 $f_c' = 25.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = As/(b_w \cdot d) = 0.00641409$   
 $As$  (tension reinf.) = 615.7522  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u \cdot d / M_u < 1 = 0.00$   
 $M_u = 1.8189791E-011$   
 $V_u = 2.9102230E-014$

From (11.5.4.8), ACI 318-14:  $V_s = 94247.78$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 150.00$

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

$2(1-s/d) = 0.75$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 318865.838$

-----  
End Of Calculation of Shear Capacity for element: beam B1 of floor 1  
At local axis: 2  
Integration Section: (b)

## Calculation No. 6

beam B1, Floor 1

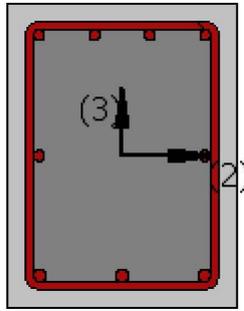
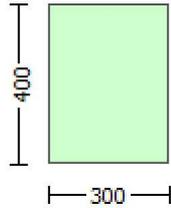
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcars

Constant Properties

-----  
 Knowledge Factor,  $\gamma = 0.90$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 #####

Section Height,  $H = 400.00$   
 Section Width,  $W = 300.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.00  
 Element Length,  $L = 1850.00$   
 Primary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
 No FRP Wrapping

-----  
 Stepwise Properties

-----  
 At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = 2740.264$   
 EDGE -B-  
 Shear Force,  $V_b = 2740.264$   
 BOTH EDGES  
 Axial Force,  $F = -189.411$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl,t} = 603.1858$   
 -Compression:  $A_{sl,c} = 923.6282$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl,ten} = 603.1858$   
 -Compression:  $A_{sl,com} = 615.7522$   
 -Middle:  $A_{sl,mid} = 307.8761$   
 -----  
 -----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.39580698$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 112670.646$   
with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 1.0175E+008$

$M_{u1+} = 9.9812E+007$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.0175E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 1.0162E+008$

$M_{u2+} = 9.9934E+007$ , 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

$M_{u2-} = 1.0162E+008$ , 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

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 2740.264$ , is the shear force acting at edge 1 for the the static loading combination

$V_2 = 2740.264$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

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

$\phi_u = 1.7580246E-005$

$M_u = 9.9812E+007$

-----  
with full section properties:

$b = 300.00$

$d = 357.00$

$d' = 42.00$

$v = 5.3592212E-005$

$N = 189.411$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_c) = 0.00553582$

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

From (5.4b), TBDY:  $\phi_u = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x} , \phi_{sh,y}) = 0.00261799$

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)

-----  
 $\phi_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 300.00$

-----  
 $\phi_{sh,y}$  (5.4d) = 0.00261799

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 400.00$

-----  
 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $\phi_c = 0.002$

$c = \text{confinement factor} = 1.00$

$\gamma_1 = 0.00140044$

$\gamma_{sh1} = 0.0044814$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

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

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06639156$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06777471$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09060316$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09249072$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04624536$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.18421297$$

$$Mu = MRc (4.14) = 9.9812E+007$$

$$u = s_u(4.1) = 1.7580246E-005$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_1$ -

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

$$u = 1.7569691E-005$$

$$\mu = 1.0175E+008$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TB DY: } c_u = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}((5.4d), \text{TB DY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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

$$p_{sh,x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal}((5.5), \text{TB DY}) = 0.032$$

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

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 389.0139$$

with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fs_2 = fs_2/1.2$ , 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  $fs_2 = fs = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = fs = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.0675854$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.06620611$   
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.0337927$   
 and confined core properties:  
 $b = 240.00$   
 $d = 328.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09220874$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09032693$   
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.04610437$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18600297$   
 $Mu = MRc (4.14) = 1.0175E+008$   
 $u = su (4.1) = 1.7569691E-005$

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

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

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

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

$$u = 1.7539903E-005$$

$$Mu = 9.9934E+007$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 466.8167$$

$$f_{y1} = 389.0139$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of  $\phi_{u,nominal}$  and  $y_1, sh_1, f_{t1}, f_{y1}$ , it is considered  
characteristic value  $f_{s1} = f_s / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 466.8167$$

$$f_{y2} = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

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

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

For calculation of  $\phi_{u,nominal}$  and  $y_2, sh_2, f_{t2}, f_{y2}$ , it is considered

characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

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

with  $f_{s2} = f_s = 389.0139$

with  $E_{s2} = E_s = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$s_{uv} = 0.00512$

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

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

Shear\_factor = 1.00

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

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

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

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

For calculation of  $e_{suv,nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , 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  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06620611$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0675854$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.0337927$

and confined core properties:

b = 240.00

d = 328.00

d' = 13.00

f<sub>cc</sub> (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09032693$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09220874$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04610437$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.18462058

Mu = MRc (4.14) = 9.9934E+007

u = su (4.1) = 1.7539903E-005

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

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
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-----  
Calculation of Mu2-  
-----  
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-----

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

u = 1.7610316E-005

Mu = 1.0162E+008

-----  
with full section properties:

b = 300.00

d = 357.00

d' = 42.00

v = 5.3592212E-005

N = 189.411

f<sub>c</sub> = 33.00

co (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00553582$

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

From (5.4b), TBDY:  $c_u = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

-----  
 $p_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 300.00$

-----  
 $p_{sh,y}$  (5.4d) = 0.00261799

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 400.00$

-----  
 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

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

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

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

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

with  $fs_1 = fs = 389.0139$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

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

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

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

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

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

with  $fs_2 = fs = 389.0139$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

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

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

with  $fsv = fs = 389.0139$

with  $Esv = Es = 200000.00$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06777471$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06639156$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$c =$  confinement factor = 1.00

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09249072$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09060316$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04624536$$

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

---

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

---

$$su (4.9) = 0.18560594$$

$$\mu = MRc (4.14) = 1.0162E+008$$

$$u = su (4.1) = 1.7610316E-005$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 284660.584$

Calculation of Shear Strength at edge 1,  $Vr1 = 284660.584$

$Vr1 = Vn ((22.5.1.1), ACI 318-14)$

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 (22.5.5.1), ACI 318-14:  $Vc = 98490.641$

= 1 (normal-weight concrete)

$fc' = 33.00$ , but  $fc^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$pw = As/(bw*d) = 0.00628319$$

$As$  (tension reinf.) = 603.1858

$bw = 300.00$

$d = 320.00$

$$Vu*d/\mu < 1 = 1.00$$

$\mu = 69262.055$

$Vu = 2740.264$

From (11.5.4.8), ACI 318-14:  $Vs = 186169.943$

$Av = 157079.633$

$fy = 555.56$

$s = 150.00$

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

$Vf ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440:  $Vs + Vf \leq 366348.956$

Calculation of Shear Strength at edge 2,  $Vr2 = 284660.584$

$Vr2 = Vn ((22.5.1.1), ACI 318-14)$

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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
As (tension reinf.) = 603.1858  
bw = 300.00  
d = 320.00  
 $V_u*d/M_u < 1 = 1.00$   
Mu = 69262.055  
Vu = 2740.264  
From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
Av = 157079.633  
fy = 555.56  
s = 150.00  
Vs has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcars

#### Constant Properties

Knowledge Factor, = 0.90  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength,  $f_s = 1.25*f_{sm} = 694.45$   
#####  
Section Height, H = 400.00  
Section Width, W = 300.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 1850.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force, Va = -8.6414578E-021  
EDGE -B-  
Shear Force, Vb = 8.6414578E-021

BOTH EDGES

Axial Force,  $F = -189.411$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 603.1858$

-Compression:  $As_c = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 508.938$

-Compression:  $As_{c,com} = 508.938$

-Middle:  $As_{mid} = 508.938$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.37228966$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 71835.924$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 6.6448E+007$

$Mu_{1+} = 6.6448E+007$ , 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

$Mu_{1-} = 6.6448E+007$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 6.6448E+007$

$Mu_{2+} = 6.6448E+007$ , 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

$Mu_{2-} = 6.6448E+007$ , 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

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination

$V_2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

Calculation of  $Mu_{1+}$

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

$\phi_u = 2.4749691E-005$

$M_u = 6.6448E+007$

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 5.5617499E-005$

$N = 189.411$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00553582$

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

From (5.4b), TBDY:  $\phi_u = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$bi_2 = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

$p_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 300.00$

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

-----  
s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

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

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$$

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

--->

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

--->

$$su \text{ (4.9)} = 0.19817337$$

$$Mu = MRc \text{ (4.14)} = 6.6448E+007$$

$$u = su \text{ (4.1)} = 2.4749691E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu1$ -

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

$$u = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$psh_{,min} = \text{Min}(psh_x, psh_y) = 0.00261799$$

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)

$$psh_x \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$psh_y \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$f_{y1} = 389.0139$   
 $s_{u1} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{u1} = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{s1\_nominal} = 0.08$ ,  
 For calculation of  $e_{s1\_nominal}$  and  $y_1, sh_1, ft_1, f_{y1}$ , it is considered  
 characteristic value  $f_{s1} = f_s/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s1} = f_s = 389.0139$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $f_{y2} = 389.0139$   
 $s_{u2} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $s_{u2} = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{s2\_nominal} = 0.08$ ,  
 For calculation of  $e_{s2\_nominal}$  and  $y_2, sh_2, ft_2, f_{y2}$ , it is considered  
 characteristic value  $f_{s2} = f_s/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, f_{y2}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = f_s = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $f_{yv} = 389.0139$   
 $s_{uv} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $y_v, sh_v, ft_v, f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = f_s = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05813483$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05813483$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05813483$   
 and confined core properties:  
 $b = 340.00$   
 $d = 228.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $s_u (4.9) = 0.19817337$   
 $M_u = M_{Rc} (4.14) = 6.6448E+007$   
 $u = s_u (4.1) = 2.4749691E-005$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_{2+}$

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

$$\mu = 2.4749691E-005$$

$$\mu_{2+} = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.00553582$$

$$\mu_{we} \text{ (5.4c)} = 0.00259035$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

$$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00261799$$

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

$$\mu_{psh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$\mu_{psh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \mu_{cc} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

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

$$\text{From table 5A.1, TBDY: } \mu_{su_1,nominal} = 0.08,$$

For calculation of  $\mu_{su_1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.

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

$$\text{with } f_{s1} = f_s = 389.0139$$

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

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07739312

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07739312

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07739312

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30  
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-----

-----  
Calculation of Mu2-  
-----  
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-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 2.4749691E-005  
Mu = 6.6448E+007

with full section properties:

b = 400.00  
d = 258.00  
d' = 42.00  
v = 5.5617499E-005  
N = 189.411  
fc = 33.00  
co (5A.5, TBDY) = 0.002  
Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00553582  
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY: cu = 0.00553582  
we (5.4c) = 0.00259035  
ase ((5.4d), TBDY) = 0.15672608  
bo = 240.00  
ho = 340.00  
bi2 = 346400.00  
psh,min = Min(psh,x , psh,y) = 0.00261799  
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 (5.4d) = 0.00349066  
Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 300.00

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 400.00

s = 150.00  
fywe = 694.45  
fce = 33.00  
From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00  
y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/d = 0.30  
su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032  
From table 5A.1, TBDY: esu1\_nominal = 0.08,  
For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.  
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.  
with fs1 = fs = 389.0139  
with Es1 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/lb,min = 0.30  
su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032  
From table 5A.1, TBDY: esu2\_nominal = 0.08,  
For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with  $fs_2 = fs = 389.0139$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$suv = 0.00512$

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

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

Shear\_factor = 1.00

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

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

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

considering characteristic value  $fsyv = fsv/1.2$ , 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  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = fs = 389.0139$

with  $Es_v = Es = 200000.00$

1 =  $Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.05813483$

2 =  $Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.05813483$

v =  $Asl_{mid}/(b \cdot d) \cdot (fsv/fc) = 0.05813483$

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.07739312$

2 =  $Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.07739312$

v =  $Asl_{mid}/(b \cdot d) \cdot (fsv/fc) = 0.07739312$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

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

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

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 192957.075$   
-----

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 192957.075$

$V_{r1} = V_n ((22.5.1.1), ACI 318-14)$   
-----

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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$

= 1 (normal-weight concrete)

$fc' = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$pw = As/(bw \cdot d) = 0.00628319$

As (tension reinf.) = 603.1858

bw = 400.00

d = 240.00

$V_u \cdot d / Mu < 1 = 0.00$

Mu = 3.4215184E-013

$$V_u = 8.6414578E-021$$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 366348.956$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$

$$V_{r2} = V_n ((22.5.1.1), ACI 318-14)$$

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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$

= 1 (normal-weight concrete)

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w \cdot d) = 0.00628319$$

$$A_s (\text{tension reinf.}) = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u \cdot d / M_u < 1 = 0.00$$

$$M_u = 3.4215797E-013$$

$$V_u = 8.6414578E-021$$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 366348.956$$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor, = 0.90

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b / l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = 4.4091E+006$   
Shear Force,  $V2 = 2.9102230E-014$   
Shear Force,  $V3 = 7491.862$   
Axial Force,  $F = -459.9979$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 615.7522$   
-Compression:  $As_c = 911.0619$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{,ten} = 615.7522$   
-Compression:  $As_{,com} = 603.1858$   
-Middle:  $As_{,mid} = 307.8761$   
Mean Diameter of Tension Reinforcement,  $Db_L = 14.00$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.00609076$   
 $u = y + p = 0.00609076$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00109076$  ((4.29), Biskinis Phd)  
 $M_y = 7.2059E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 588.5156  
From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 1.2960E+013$

Calculation of Yielding Moment  $M_y$

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

$y = \text{Min}(y_{,ten}, y_{,com})$   
 $y_{,ten} = 5.8357660E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/d)^{2/3}) = 311.2112$   
 $d = 358.00$   
 $y = 0.25519213$   
 $A = 0.01422991$   
 $B = 0.00802707$   
with  $p_t = 0.00573326$   
 $p_c = 0.00561626$   
 $p_v = 0.00286663$   
 $N = 459.9979$   
 $b = 300.00$   
 $" = 0.12011173$   
 $y_{,comp} = 2.4096452E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.25503248$   
 $A = 0.01420641$   
 $B = 0.00801331$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

- Calculation of  $p$  -

From table 10-7:  $p = 0.005$

with:

- Condition iv occurred

Beam controlled by inadequate embedment into beam-column joint:  
( $b/d < 1$  and With Lapping in the Vicinity of the End Regions

- Condition i occurred

Beam controlled by flexure:  $V_p/V_o \leq 1$

shear control ratio  $V_p/V_o = 0.39580698$

- Transverse Reinforcement: NC

- Stirrup Spacing  $> d/3$

- Low ductility demand,  $\lambda / y < 2$  (table 10-6, ASCE 41-17)

$= 1.1318832E-005$

- Stirrup Spacing  $\leq d/2$

$d = 358.00$

$s = 150.00$

- Strength provided by hoops  $V_s < 3/4 * \text{design Shear}$

$V_s = 186169.943$ , already given in calculation of shear control ratio

design Shear = 7491.862

- ( $\lambda - \lambda'$ )/ bal = -0.16136132

$= A_{st}/(b_w*d) = 0.00573326$

Tension Reinf Area:  $A_{st} = 615.7522$

$\lambda' = A_{sc}/(b_w*d) = 0.00848289$

Compression Reinf Area:  $A_{sc} = 911.0619$

From (B-1), ACI 318-11: bal = 0.01704017

$f_c = 33.00$

$f_y = 555.56$

From 10.2.7.3, ACI 318-11:  $\lambda = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too):  $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + y) = 0.51922877$

$y = 0.0027778$

-  $V/(b_w*d*f_c^{0.5}) = 0.14623514$ , NOTE: units in lb & in

$b_w = 300.00$

-----  
End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (b)  
-----

## Calculation No. 7

beam B1, Floor 1

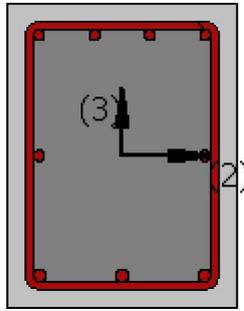
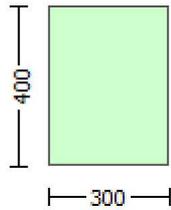
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 4.3814E+006$

Shear Force,  $V_a = -2011.333$

EDGE -B-

Bending Moment,  $M_b = 4.4091E+006$

Shear Force,  $V_b = 7491.862$

BOTH EDGES

Axial Force,  $F = -459.9979$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{s,t} = 615.7522$

-Compression:  $A_{s,c} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{s,ten} = 615.7522$

-Compression:  $A_{s,com} = 603.1858$

-Middle:  $A_{s,mid} = 307.8761$

Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 14.00$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 * V_n = 250043.372$

$V_n ((22.5.1.1), ACI 318-14) = 250043.372$

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 (22.5.5.1), ACI 318-14:  $V_c = 82491.763$   
= 1 (normal-weight concrete)  
 $f'_c = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00641409$   
 $A_s$  (tension reinf.) = 615.7522  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/\mu < 1 = 0.54374086$   
 $\mu = 4.4091E+006$   
 $V_u = 7491.862$   
From (11.5.4.8), ACI 318-14:  $V_s = 167551.608$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 318865.838$

End Of Calculation of Shear Capacity for element: beam B1 of floor 1  
At local axis: 3  
Integration Section: (b)

## Calculation No. 8

beam B1, Floor 1

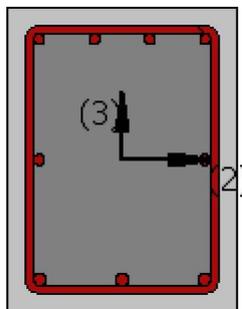
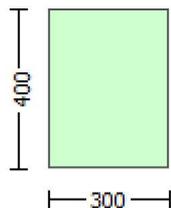
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\mu$ )

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 3  
(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

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

#####

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 2740.264$

EDGE -B-

Shear Force,  $V_b = 2740.264$

BOTH EDGES

Axial Force,  $F = -189.411$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 603.1858$

-Compression:  $A_{sl,c} = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 603.1858$

-Compression:  $A_{sl,com} = 615.7522$

-Middle:  $A_{sl,mid} = 307.8761$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.39580698$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u * l_n / 2 = 112670.646$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.0175E+008$

$M_{u1+} = 9.9812E+007$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.0175E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.0162E+008$

$M_{u2+} = 9.9934E+007$ , 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

$M_{u2-} = 1.0162E+008$ , 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

and

$\pm w_u * l_n = (|V_1| + |V_2|) / 2$

with

V1 = 2740.264, is the shear force acting at edge 1 for the the static loading combination  
V2 = 2740.264, is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of Mu1+  
-----

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

$$\mu = 1.7580246E-005$$

$$Mu = 9.9812E+007$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 5.3592212E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

-----  
$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

-----  
$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

-----  
$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

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

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

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.06639156$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.06777471$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09060316$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09249072$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.04624536$$

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

--->

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

--->

$$su (4.9) = 0.18421297$$

$$Mu = MRc (4.14) = 9.9812E+007$$

$$u = su (4.1) = 1.7580246E-005$$

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

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

-----  
Calculation of  $Mu_1$ -  
-----  
-----

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

$$u = 1.7569691E-005$$

$$Mu = 1.0175E+008$$

-----  
with full section properties:

b = 300.00  
d = 358.00  
d' = 43.00  
v = 5.3442513E-005  
N = 189.411

fc = 33.00  
co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00553582$

we (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

-----  
psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

-----  
s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/d = 0.30

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

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

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

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

with  $\text{fs1} = \text{fs} = 389.0139$

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

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

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

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

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

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

with  $\text{fs2} = \text{fs} = 389.0139$

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

yv = 0.00140044

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

$$lo/lo_{min} = lb/ld = 0.30$$

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

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.0675854$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.06620611$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.0337927$$

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.09220874$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.09032693$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.04610437$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$$su (4.9) = 0.18600297$$

$$Mu = MRc (4.14) = 1.0175E+008$$

$$u = su (4.1) = 1.7569691E-005$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu_{2+}$

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

$$u = 1.7539903E-005$$

$$Mu = 9.9934E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$we (5.4c) = 0.00259035$$

$$ase ((5.4d), TBDY) = 0.15672608$$

$$bo = 240.00$$

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

-----  
psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

-----  
s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/lb = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06620611$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0675854$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.0337927$

and confined core properties:

$b = 240.00$

$d = 328.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 33.00$

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

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09032693$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09220874$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04610437$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su \text{ (4.9)} = 0.18462058$

$Mu = MRc \text{ (4.14)} = 9.9934E+007$

$u = su \text{ (4.1)} = 1.7539903E-005$

-----  
Calculation of ratio  $l_b/d$

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

Calculation of  $Mu_2$ -  
-----  
-----

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

$u = 1.7610316E-005$

$Mu = 1.0162E+008$   
-----

with full section properties:

$b = 300.00$

$d = 357.00$

$d' = 42.00$

$v = 5.3592212E-005$

$N = 189.411$

$f_c = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00553582$

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

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e \text{ (5.4c)} = 0.00259035$

$ase \text{ ((5.4d), TBDY)} = 0.15672608$

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

$psh_{,min} = \text{Min}(psh_x, psh_y) = 0.00261799$

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)

-----  
 $psh_x \text{ (5.4d)} = 0.00349066$

$A_{sh} = A_{stir} \cdot ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 300.00$   
-----

$psh_y \text{ (5.4d)} = 0.00261799$

$A_{sh} = A_{stir} \cdot ns = 78.53982$

No stirrups, ns = 2.00  
bk = 400.00

s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

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

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

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

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

lo/lou,min = lb/lb = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06777471

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06639156

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.03388736

and confined core properties:

b = 240.00  
d = 327.00  
d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.09249072$$

$$2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.09060316$$

$$v = A_{s1,mid}/(b*d)*(f_{sv}/f_c) = 0.04624536$$

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

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

$$s_u(4.9) = 0.18560594$$

$$\mu_u = M_{Rc}(4.14) = 1.0162E+008$$

$$u = s_u(4.1) = 1.7610316E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 284660.584$

Calculation of Shear Strength at edge 1,  $V_{r1} = 284660.584$   
 $V_{r1} = V_n$  ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'V<sub>w</sub>' is replaced by 'V<sub>w</sub> + f\*V<sub>f</sub>'  
 where V<sub>f</sub> is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
 = 1 (normal-weight concrete)  
 $f'_c = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/\mu_u < 1 = 1.00$   
 $\mu_u = 69262.055$   
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

Calculation of Shear Strength at edge 2,  $V_{r2} = 284660.584$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'V<sub>w</sub>' is replaced by 'V<sub>w</sub> + f\*V<sub>f</sub>'  
 where V<sub>f</sub> is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
 = 1 (normal-weight concrete)  
 $f'_c = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/\mu_u < 1 = 1.00$   
 $\mu_u = 69262.055$   
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 366348.956

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcars

Constant Properties

Knowledge Factor, = 0.90  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 33.00  
New material of Primary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00

#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength, fs = 1.25\*fsm = 694.45

#####  
Section Height, H = 400.00  
Section Width, W = 300.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 1850.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with lo/lo,min = 0.30  
No FRP Wrapping

Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force, Va = -8.6414578E-021  
EDGE -B-  
Shear Force, Vb = 8.6414578E-021  
BOTH EDGES  
Axial Force, F = -189.411  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: Aslt = 603.1858  
-Compression: Aslc = 923.6282  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension: Asl,ten = 508.938  
-Compression: Asl,com = 508.938  
-Middle: Asl,mid = 508.938

Calculation of Shear Capacity ratio , Ve/Vr = 0.37228966  
Member Controlled by Flexure (Ve/Vr < 1)  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln ± wu\*ln/2 = 71835.924  
with  
Mpr1 = Max(Mu1+ , Mu1-) = 6.6448E+007

$Mu_{1+} = 6.6448E+007$ , 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

$Mu_{1-} = 6.6448E+007$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr2 = \text{Max}(Mu_{2+}, Mu_{2-}) = 6.6448E+007$

$Mu_{2+} = 6.6448E+007$ , 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

$Mu_{2-} = 6.6448E+007$ , 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

and

$\pm wu*ln = (|V1| + |V2|)/2$

with

$V1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination

$V2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

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

$u = 2.4749691E-005$

$Mu = 6.6448E+007$   
-----

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 5.5617499E-005$

$N = 189.411$

$fc = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$

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

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e (5.4c) = 0.00259035$

$a_{se} ((5.4d), TBDY) = 0.15672608$

$bo = 240.00$

$ho = 340.00$

$bi^2 = 346400.00$

$psh, \text{min} = \text{Min}(psh, x, psh, y) = 0.00261799$

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

-----  
 $psh, x (5.4d) = 0.00349066$

$A_{sh} = A_{stir} * ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 300.00$   
-----

$psh, y (5.4d) = 0.00261799$

$A_{sh} = A_{stir} * ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 400.00$   
-----

$s = 150.00$

$fyw_e = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 466.8167$

$fy1 = 389.0139$

$su1 = 0.00512$

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

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

Shear\_factor = 1.00

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

$$s_u1 = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s1\_nominal} = 0.08,$$

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

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

$$\text{with } f_{s1} = f_s = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$s_u2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s2\_nominal} = 0.08,$$

For calculation of  $e_{s2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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.

$$\text{with } f_{s2} = f_s = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{u,v} = 0.00512$$

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

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

$$s_{u,v} = 0.4 * e_{s_{u,v}}\_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s_{u,v}}\_{nominal} = 0.08,$$

considering characteristic value  $f_{s_{y,v}} = f_{s_{v}}/1.2$ , from table 5.1, TBDY  
For calculation of  $e_{s_{u,v}}\_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $f_{s_{y,v}} = f_{s_{v}}/1.2$ , from table 5.1, TBDY.

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

$$\text{with } f_{s_{v}} = f_s = 389.0139$$

$$\text{with } E_{s_{v}} = E_s = 200000.00$$

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.05813483$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.05813483$$

$$v = A_{s1,mid}/(b*d) * (f_{s_{v}}/f_c) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.07739312$$

$$2 = A_{s1,com}/(b*d) * (f_{s2}/f_c) = 0.07739312$$

$$v = A_{s1,mid}/(b*d) * (f_{s_{v}}/f_c) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$$s_u (4.9) = 0.19817337$$

$$M_u = M_{Rc} (4.14) = 6.6448E+007$$

$$u = s_u (4.1) = 2.4749691E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Mu1-

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

$$\mu = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

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

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

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_2_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_2_{nominal} = 0.08$ ,  
 For calculation of  $esu_2_{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = fs = 389.0139$   
 with  $Es_2 = Es = 200000.00$

$y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.30$   
 $su_v = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 389.0139$   
 with  $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.05813483$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.05813483$   
 $v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.05813483$

and confined core properties:

$b = 340.00$   
 $d = 228.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.07739312$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.07739312$   
 $v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.07739312$

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

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

--->  
 $su (4.9) = 0.19817337$   
 $Mu = MRc (4.14) = 6.6448E+007$   
 $u = su (4.1) = 2.4749691E-005$

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

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

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

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

$u = 2.4749691E-005$   
 $Mu = 6.6448E+007$

-----  
 with full section properties:

$b = 400.00$

d = 258.00

d' = 42.00

v = 5.5617499E-005

N = 189.411

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$

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

From (5.4b), TBDY:  $cu = 0.00553582$

we (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min =  $\text{Min}(\text{psh},x, \text{psh},y) = 0.00261799$

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 (5.4d) = 0.00349066

Ash =  $\text{Astir} * ns = 78.53982$

No stirrups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash =  $\text{Astir} * ns = 78.53982$

No stirrups, ns = 2.00

bk = 400.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

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

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

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

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value  $\text{fsy1} = \text{fs1}/1.2$ , 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  $\text{fs1} = \text{fs} = 389.0139$

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min =  $lb/lb,\text{min} = 0.30$

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

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

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value  $\text{fsy2} = \text{fs2}/1.2$ , 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  $\text{fs2} = \text{fs} = 389.0139$

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

yv = 0.00140044

shv = 0.0044814

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

$$lo/lo_{u,min} = lb/d = 0.30$$

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

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.05813483$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.05813483$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.07739312$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.07739312$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.19817337$$

$$Mu = MRc (4.14) = 6.6448E+007$$

$$u = su (4.1) = 2.4749691E-005$$

Calculation of ratio  $lb/d$

Inadequate Lap Length with  $lb/d = 0.30$

Calculation of  $Mu2$ -

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

$$u = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$we (5.4c) = 0.00259035$$

$$ase ((5.4d), TBDY) = 0.15672608$$

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$$

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)

$$psh,x (5.4d) = 0.00349066$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 300.00$$

$$psh,y (5.4d) = 0.00261799$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

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

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

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

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

$y2, sh2, ft2, fy2$ , are also multiplied by  $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

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

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

1 =  $A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05813483$

2 =  $A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05813483$

v =  $A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05813483$

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

f<sub>cc</sub> (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$

2 =  $A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$

v =  $A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

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

-----  
Inadequate Lap Length with lb/l<sub>d</sub> = 0.30  
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 192957.075$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 192957.075$

$V_{r1} = V_n$  ((22.5.1.1), ACI 318-14)

-----  
NOTE: In expression (22.5.1.1) 'V<sub>w</sub>' is replaced by 'V<sub>w</sub> + f\*V<sub>f</sub>'  
where V<sub>f</sub> is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (22.5.5.1), ACI 318-14:  $V_c = 88236.482$

= 1 (normal-weight concrete)

$f'_c = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$p_w = A_s/(b_w*d) = 0.00628319$

$A_s$  (tension reinf.) = 603.1858

$b_w = 400.00$

d = 240.00

$V_u*d/M_u < 1 = 0.00$

$M_u = 3.4215184E-013$

$V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$

$A_v = 157079.633$

$f_y = 555.56$

s = 150.00

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

$2(1-s/d) = 0.75$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$   
-----

Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$

$V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

-----  
NOTE: In expression (22.5.1.1) 'V<sub>w</sub>' is replaced by 'V<sub>w</sub> + f\*V<sub>f</sub>'  
where V<sub>f</sub> is the contribution of FRPs (11.3), ACI 440).

-----  
From Table (22.5.5.1), ACI 318-14:  $V_c = 88236.482$

= 1 (normal-weight concrete)

$f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w \cdot d) = 0.00628319$

$A_s$  (tension reinf.) = 603.1858

$b_w = 400.00$

$d = 240.00$

$V_u \cdot d / M_u < 1 = 0.00$

$M_u = 3.4215797E-013$

$V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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

$2(1-s/d) = 0.75$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

-----  
End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcars

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b / l_d = 0.30$

No FRP Wrapping

-----  
Stepwise Properties

Bending Moment,  $M = 1.8189791E-011$

Shear Force,  $V_2 = 2.9102230E-014$

Shear Force,  $V_3 = 7491.862$

Axial Force,  $F = -459.9979$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 615.7522$

-Compression:  $A_{sl,c} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 508.938$

-Compression:  $A_{sl,com} = 508.938$

-Middle:  $A_{sl,mid} = 508.938$

Mean Diameter of Tension Reinforcement,  $Db_L = 14.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u,R = 1.0^*$   $u = 0.00706586$   
 $u = y + p = 0.00706586$

-----  
- Calculation of  $y$  -  
-----

$y = (M_y * L_s / 3) / E_{eff} = 0.00206586$  ((4.29), Biskinis Phd))  
 $M_y = 4.8843E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 925.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 7.2898E+012$

-----  
Calculation of Yielding Moment  $M_y$   
-----

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 8.1950237E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 311.2112$   
 $d = 258.00$   
 $y = 0.26403826$   
 $A = 0.01480903$   
 $B = 0.0086159$   
with  $p_t = 0.00493157$   
 $p_c = 0.00493157$   
 $p_v = 0.00493157$   
 $N = 459.9979$   
 $b = 400.00$   
 $" = 0.1627907$   
 $y_{comp} = 3.2314820E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.26388224$   
 $A = 0.01478458$   
 $B = 0.00860158$   
with  $E_s = 200000.00$

-----  
Calculation of ratio  $l_b / d$   
-----

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

- Calculation of  $p$  -  
-----

From table 10-7:  $p = 0.005$

with:

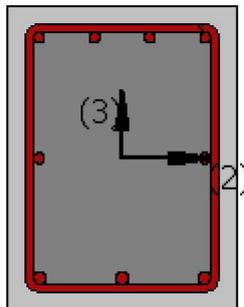
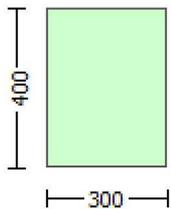
- Condition iv occurred  
Beam controlled by inadequate embedment into beam-column joint:  
( $l_b / d < 1$  and With Lapping in the Vicinity of the End Regions)
- Condition i occurred  
Beam controlled by flexure:  $V_p / V_o \leq 1$   
shear control ratio  $V_p / V_o = 0.37228966$
- Transverse Reinforcement: NC
- Stirrup Spacing  $> d / 3$
- Low ductility demand,  $\lambda / y < 2$  (table 10-6, ASCE 41-17)  
=  $-6.8371455E-022$
- Stirrup Spacing  $> d / 2$   
 $d = 258.00$   
 $s = 150.00$
- Strength provided by hoops  $V_s < 3/4 * \text{design Shear}$   
 $V_s = 139627.457$ , already given in calculation of shear control ratio  
design Shear =  $2.9102230E-014$

$\rho = \frac{A_{st}}{b_w \cdot d} = 0.00596659$   
 Tension Reinf Area:  $A_{st} = 615.7522$   
 $\rho' = \frac{A_{sc}}{b_w \cdot d} = 0.00882812$   
 Compression Reinf Area:  $A_{sc} = 911.0619$   
 From (B-1), ACI 318-11:  $\rho_{bal} = 0.01704017$   
 $f_c = 33.00$   
 $f_y = 555.56$   
 From 10.2.7.3, ACI 318-11:  $\beta_1 = 0.65$   
 From fig R10.3.3, ACI 318-11 (Ence 454, too):  $\frac{c_b}{d} = \frac{87000}{87000 + f_y} = 0.003 / (0.003 + f_y) = 0.51922877$   
 $\rho_y = 0.0027778$   
 $V / (b_w \cdot d \cdot f_c^{0.5}) = 5.9117060E-019$ , NOTE: units in lb & in  
 $b_w = 400.00$

End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1  
 At local axis: 3  
 Integration Section: (b)

## Calculation No. 9

beam B1, Floor 1  
 Limit State: Life Safety (data interpolation between analysis steps 1 and 2)  
 Analysis: Uniform +X  
 Check: Shear capacity  $V_{Rd}$   
 Edge: Start  
 Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1  
 At local axis: 2  
 Integration Section: (a)  
 Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Section Height,  $H = 400.00$   
Section Width,  $W = 300.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 1850.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -1.1438410E-010$   
Shear Force,  $V_a = -4.6128812E-014$   
EDGE -B-  
Bending Moment,  $M_b = 2.9032116E-011$   
Shear Force,  $V_b = 4.6128812E-014$   
BOTH EDGES  
Axial Force,  $F = -618.3078$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 603.1858$   
-Compression:  $A_{sc} = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 508.938$   
-Compression:  $A_{sc,com} = 508.938$   
-Middle:  $A_{s,mid} = 508.938$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 14.66667$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 171047.78$   
 $V_n$  ((22.5.1.1), ACI 318-14) = 171047.78

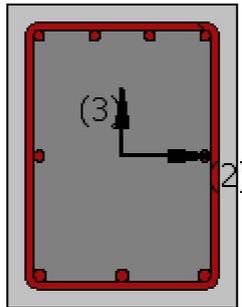
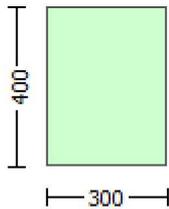
NOTE: In expression (22.5.1.1) ' $V_w$ ' is replaced by ' $V_w + f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs ((11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14:  $V_c = 76800.00$   
= 1 (normal-weight concrete)  
 $f_c' = 25.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa ((22.5.3.1), ACI 318-14)  
 $\rho_w = A_s/(b_w \cdot d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u \cdot d / M_u < 1 = 0.00$   
 $M_u = 1.1438410E-010$   
 $V_u = 4.6128812E-014$   
From ((11.5.4.8), ACI 318-14:  $V_s = 94247.78$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 150.00$   
 $V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17, 10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From ((11-11), ACI 440:  $V_s + V_f \leq 318865.838$

End Of Calculation of Shear Capacity for element: beam B1 of floor 1  
 At local axis: 2  
 Integration Section: (a)

## Calculation No. 10

beam B1, Floor 1  
 Limit State: Life Safety (data interpolation between analysis steps 1 and 2)  
 Analysis: Uniform +X  
 Check: Chord rotation capacity (  $\theta$  )  
 Edge: Start  
 Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
 At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 #####  
 Section Height,  $H = 400.00$   
 Section Width,  $W = 300.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.00  
 Element Length,  $L = 1850.00$   
 Primary Member

Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = 2740.264$   
EDGE -B-  
Shear Force,  $V_b = 2740.264$   
BOTH EDGES  
Axial Force,  $F = -189.411$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 603.1858$   
-Compression:  $A_{sc} = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 603.1858$   
-Compression:  $A_{sc,com} = 615.7522$   
-Middle:  $A_{sc,mid} = 307.8761$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.39580698$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 112670.646$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.0175E+008$   
 $\mu_{u1+} = 9.9812E+007$ , 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  
 $\mu_{u1-} = 1.0175E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.0162E+008$   
 $\mu_{u2+} = 9.9934E+007$ , 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  
 $\mu_{u2-} = 1.0162E+008$ , 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  
and  
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$   
with  
 $V_1 = 2740.264$ , is the shear force acting at edge 1 for the the static loading combination  
 $V_2 = 2740.264$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $\mu_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 1.7580246E-005$   
 $M_u = 9.9812E+007$

-----  
with full section properties:

$b = 300.00$   
 $d = 357.00$   
 $d' = 42.00$   
 $v = 5.3592212E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $\omega (5A.5, TBDY) = 0.002$   
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

-----  
 $p_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 300.00$   
-----

$p_{sh,y}$  (5.4d) = 0.00261799

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 400.00$   
-----

$s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

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

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

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

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

with  $fs_1 = fs = 389.0139$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

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

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

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

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

with  $fs_2 = fs = 389.0139$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

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

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

From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $e_{suv\_nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{sv} = f_s = 389.0139$   
with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06639156$   
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06777471$   
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03388736$

and confined core properties:

$b = 240.00$   
 $d = 327.00$   
 $d' = 12.00$   
 $f_{cc}$  (5A.2, TBDY) = 33.00  
 $cc$  (5A.5, TBDY) = 0.002  
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09060316$   
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09249072$   
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04624536$

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

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

--->  
 $su$  (4.9) = 0.18421297  
 $Mu = MRc$  (4.14) = 9.9812E+007  
 $u = su$  (4.1) = 1.7580246E-005

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

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

-----  
Calculation of  $Mu_1$ -  
-----  
-----

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

$u = 1.7569691E-005$   
 $Mu = 1.0175E+008$

-----  
with full section properties:

$b = 300.00$   
 $d = 358.00$   
 $d' = 43.00$   
 $v = 5.3442513E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $cc$  (5A.5, TBDY) = 0.002  
Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $cu = 0.00553582$   
 $w_e$  (5.4c) = 0.00259035  
 $a_{se}$  ((5.4d), TBDY) = 0.15672608  
 $bo = 240.00$   
 $ho = 340.00$   
 $bi_2 = 346400.00$   
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

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)

-----  
 $psh,x$  (5.4d) = 0.00349066  
 $A_{stir} = A_{stir} \cdot n_s = 78.53982$   
No stirrups,  $n_s = 2.00$

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 400.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.0675854

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06620611

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.0337927

and confined core properties:

b = 240.00

d = 328.00

d' = 13.00  
fcc (5A.2, TBDY) = 33.00  
cc (5A.5, TBDY) = 0.002  
c = confinement factor = 1.00  
1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09220874  
2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09032693  
v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04610437  
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

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

--->  
su (4.9) = 0.18600297  
Mu = MRc (4.14) = 1.0175E+008  
u = su (4.1) = 1.7569691E-005

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

-----  
Inadequate Lap Length with lb/l<sub>d</sub> = 0.30  
-----  
-----

-----  
Calculation of Mu<sub>2+</sub>  
-----  
-----

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

u = 1.7539903E-005  
Mu = 9.9934E+007

-----  
with full section properties:

b = 300.00  
d = 358.00  
d' = 43.00  
v = 5.3442513E-005  
N = 189.411  
fc = 33.00  
co (5A.5, TBDY) = 0.002  
Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00553582  
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY: cu = 0.00553582  
we (5.4c) = 0.00259035  
ase ((5.4d), TBDY) = 0.15672608  
bo = 240.00  
ho = 340.00  
bi2 = 346400.00  
psh,min = Min(psh,x , psh,y) = 0.00261799  
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 (5.4d) = 0.00349066  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 300.00

-----  
psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

-----  
s = 150.00  
fywe = 694.45  
fce = 33.00  
From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00  
y1 = 0.00140044

$sh1 = 0.0044814$   
 $ft1 = 466.8167$   
 $fy1 = 389.0139$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 0.30$   
 $su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1$ ,  $sh1,ft1,fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1$ ,  $sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = fs = 389.0139$   
 with  $Es1 = Es = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 466.8167$   
 $fy2 = 389.0139$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/lb,min = 0.30$   
 $su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2$ ,  $sh2,ft2,fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1$ ,  $sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = fs = 389.0139$   
 with  $Es2 = Es = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1$ ,  $sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 389.0139$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.06620611$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.0675854$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.0337927$   
 and confined core properties:  
 $b = 240.00$   
 $d = 328.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.09032693$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.09220874$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04610437$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18462058$

$$\begin{aligned} \text{Mu} &= \text{MRc (4.14)} = 9.9934\text{E}+007 \\ u &= \text{su (4.1)} = 1.7539903\text{E}-005 \end{aligned}$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\text{Mu}_2$

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

$$\begin{aligned} u &= 1.7610316\text{E}-005 \\ \text{Mu} &= 1.0162\text{E}+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 300.00 \\ d &= 357.00 \\ d' &= 42.00 \\ v &= 5.3592212\text{E}-005 \\ N &= 189.411 \\ f_c &= 33.00 \\ c_o \text{ (5A.5, TBDY)} &= 0.002 \\ \text{Final value of } c_u: c_u^* &= \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582 \\ \text{The Shear\_factor is considered equal to 1 (pure moment strength)} \\ \text{From (5.4b), TBDY: } c_u &= 0.00553582 \\ w_e \text{ (5.4c)} &= 0.00259035 \\ a_{se} \text{ ((5.4d), TBDY)} &= 0.15672608 \\ b_o &= 240.00 \\ h_o &= 340.00 \\ b_{i2} &= 346400.00 \\ p_{sh,min} &= \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799 \\ \text{Expression ((5.4d), TBDY) for } p_{sh,min} &\text{ has been multiplied by 0.3 according to 15.7.1.3 for members without} \\ \text{earthquake detailing (90}^\circ \text{ closed stirrups)} \end{aligned}$$

$$\begin{aligned} p_{sh,x} \text{ (5.4d)} &= 0.00349066 \\ A_{sh} &= A_{stir} * n_s = 78.53982 \\ \text{No stirrups, } n_s &= 2.00 \\ b_k &= 300.00 \end{aligned}$$

$$\begin{aligned} p_{sh,y} \text{ (5.4d)} &= 0.00261799 \\ A_{sh} &= A_{stir} * n_s = 78.53982 \\ \text{No stirrups, } n_s &= 2.00 \\ b_k &= 400.00 \end{aligned}$$

$$\begin{aligned} s &= 150.00 \\ f_{ywe} &= 694.45 \\ f_{ce} &= 33.00 \\ \text{From ((5.A5), TBDY), TBDY: } c_c &= 0.002 \\ c &= \text{confinement factor} = 1.00 \\ y_1 &= 0.00140044 \\ sh_1 &= 0.0044814 \\ ft_1 &= 466.8167 \\ fy_1 &= 389.0139 \\ su_1 &= 0.00512 \end{aligned}$$

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

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

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

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

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

with  $f_{s1} = f_s = 389.0139$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = f_s = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsy_v = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsy_v = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = f_s = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.06777471$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.06639156$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.03388736$

and confined core properties:

$b = 240.00$   
 $d = 327.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.09249072$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.09060316$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04624536$

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

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18560594$   
 $Mu = MRc (4.14) = 1.0162E+008$   
 $u = su (4.1) = 1.7610316E-005$

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

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

-----  
 Calculation of Shear Strength  $V_r = Min(V_{r1}, V_{r2}) = 284660.584$   
 -----

Calculation of Shear Strength at edge 1,  $V_{r1} = 284660.584$   
 $V_{r1} = V_n$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s / (b_w \cdot d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u \cdot d / \mu_u < 1 = 1.00$   
 $\mu_u = 69262.055$   
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

Calculation of Shear Strength at edge 2,  $V_{r2} = 284660.584$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s / (b_w \cdot d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u \cdot d / \mu_u < 1 = 1.00$   
 $\mu_u = 69262.055$   
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou, \min} = 0.30$

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2

EDGE -A-

Shear Force,  $V_a = -8.6414578E-021$

EDGE -B-

Shear Force,  $V_b = 8.6414578E-021$

BOTH EDGES

Axial Force,  $F = -189.411$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 603.1858$

-Compression:  $A_{sc} = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st, \text{ten}} = 508.938$

-Compression:  $A_{st, \text{com}} = 508.938$

-Middle:  $A_{st, \text{mid}} = 508.938$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.37228966$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 71835.924$   
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 6.6448E+007$

$M_{u1+} = 6.6448E+007$ , 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

$M_{u1-} = 6.6448E+007$ , 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 6.6448E+007$

$M_{u2+} = 6.6448E+007$ , 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

$M_{u2-} = 6.6448E+007$ , 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

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination

$V_2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $M_{u1+}$

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

$\phi_u = 2.4749691E-005$

Mu = 6.6448E+007

with full section properties:

b = 400.00

d = 258.00

d' = 42.00

v = 5.5617499E-005

N = 189.411

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00553582

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

From (5.4b), TBDY: cu = 0.00553582

we (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with  $f_{s2} = f_s = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = f_s = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.05813483$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.05813483$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.05813483$   
 and confined core properties:  
 $b = 340.00$   
 $d = 228.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.07739312$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.07739312$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.07739312$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.19817337$   
 $Mu = MRc (4.14) = 6.6448E+007$   
 $u = su (4.1) = 2.4749691E-005$

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

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

-----  
 Calculation of  $Mu_1$ -  
 -----  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 2.4749691E-005$   
 $Mu = 6.6448E+007$   
 -----

with full section properties:

$b = 400.00$   
 $d = 258.00$   
 $d' = 42.00$   
 $v = 5.5617499E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00553582$

we (5.4c) = 0.00259035  
ase ((5.4d), TBDY) = 0.15672608  
bo = 240.00  
ho = 340.00  
bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799  
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 (5.4d) = 0.00349066  
Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 300.00

-----  
psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 400.00

-----  
s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

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

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05813483$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05813483$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05813483$

and confined core properties:

$b = 340.00$

$d = 228.00$

$d' = 12.00$

$f_{cc}$  (5A.2, TBDY) = 33.00

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

$c$  = confinement factor = 1.00

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.07739312$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07739312$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07739312$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.19817337

$Mu = MR_c$  (4.14) = 6.6448E+007

$u = su$  (4.1) = 2.4749691E-005

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

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

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

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

$u = 2.4749691E-005$

$Mu = 6.6448E+007$   
-----

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 5.5617499E-005$

$N = 189.411$

$f_c = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00553582$

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

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

-----  
 $p_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$bk = 300.00$

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

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

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

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

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

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

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

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

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

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00  
d = 228.00  
d' = 12.00

$$fcc(5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07739312$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.07739312$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su(4.9) = 0.19817337$$

$$Mu = MRc(4.14) = 6.6448E+007$$

$$u = su(4.1) = 2.4749691E-005$$

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

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
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-----  
Calculation of  $Mu_2$ -  
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-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$we(5.4c) = 0.00259035$$

$$ase((5.4d), TBDY) = 0.15672608$$

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$$

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)

$$psh,x(5.4d) = 0.00349066$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 300.00$$

$$psh,y(5.4d) = 0.00261799$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

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

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05813483$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.05813483$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07739312$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07739312$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.19817337$$

$$Mu = MRc (4.14) = 6.6448E+007$$

$$u = su(4.1) = 2.4749691E-005$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 192957.075$

Calculation of Shear Strength at edge 1,  $V_{r1} = 192957.075$   
 $V_{r1} = V_n$  ((22.5.1.1), ACI 318-14)

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

From Table (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/\mu < 1 = 0.00$   
 $\mu = 3.4215184E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

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

From Table (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/\mu < 1 = 0.00$   
 $\mu = 3.4215797E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = 6.9042E+006$

Shear Force,  $V_2 = -4.6128812E-014$

Shear Force,  $V_3 = -4791.309$

Axial Force,  $F = -618.3078$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 603.1858$

-Compression:  $A_{sc} = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 603.1858$

-Compression:  $A_{sc,com} = 615.7522$

-Middle:  $A_{st,mid} = 307.8761$

Mean Diameter of Tension Reinforcement,  $DbL = 16.00$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = 1.0^* \phi_u = 0.02261926$

$\phi_u = \phi_y + \phi_p = 0.02261926$

- Calculation of  $\phi_y$  -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00261926$  ((4.29), Biskinis Phd)

$M_y = 7.0670E+007$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1440.988

From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 1.2960E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

$\phi_y = \text{Min}(\phi_{y,ten}, \phi_{y,com})$

$\phi_{y,ten} = 5.8351625E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 311.2112$

d = 357.00  
y = 0.25302858  
A = 0.01427452  
B = 0.00793336  
with pt = 0.00563199  
pc = 0.00574932  
pv = 0.00287466  
N = 618.3078  
b = 300.00  
" = 0.11764706  
y\_comp = 2.4376298E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.25281081  
A = 0.01424285  
B = 0.00791481  
with Es = 200000.00

-----  
-----  
Calculation of ratio lb/d

-----  
Inadequate Lap Length with lb/d = 0.30

-----  
- Calculation of p -

-----  
From table 10-7: p = 0.02

with:

- Condition iv occurred

Beam controlled by inadequate embedment into beam-column joint:  
(lb/d < 1 and With Lapping in the Vicinity of the End Regions

- Condition i occurred

Beam controlled by flexure:  $V_p/V_o \leq 1$   
shear control ratio  $V_p/V_o = 0.39580698$

- Transverse Reinforcement: NC

- Stirrup Spacing > d/3

- Low ductility demand,  $\lambda / y < 2$  (table 10-6, ASCE 41-17)  
= 6.1566510E-005

- Stirrup Spacing  $\leq d/2$

d = 357.00

s = 150.00

- Strength provided by hoops  $V_s < 3/4$ \*design Shear

$V_s = 186169.943$ , already given in calculation of shear control ratio  
design Shear = 4791.309

- ( $\lambda - \lambda'$ )/ bal = -0.17558466

=  $A_{sl}/(b_w*d) = 0.00563199$

Tension Reinf Area:  $A_{sl} = 603.1858$

$\lambda' = A_{slc}/(b_w*d) = 0.00862398$

Compression Reinf Area:  $A_{slc} = 923.6282$

From (B-1), ACI 318-11: bal = 0.01704017

fc = 33.00

fy = 555.56

From 10.2.7.3, ACI 318-11:  $\lambda = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too):  $87000/(87000+fy) = c_b/d_t = 0.003/(0.003+ y) = 0.51922877$

y = 0.0027778

-  $V/(b_w*d*fc^{0.5}) = 0.09378448$ , NOTE: units in lb & in

$b_w = 300.00$

-----  
End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (a)

## Calculation No. 11

beam B1, Floor 1

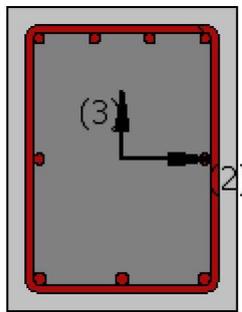
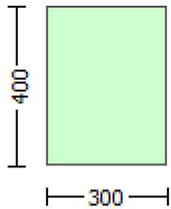
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = l_b/d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 6.9042E+006$

Shear Force,  $V_a = -4791.309$

EDGE -B-

Bending Moment,  $M_b = 7.0292E+006$

Shear Force,  $V_b = 10271.838$

BOTH EDGES

Axial Force,  $F = -618.3078$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 603.1858$

-Compression:  $A_{sc} = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 603.1858$

-Compression:  $A_{sc,com} = 615.7522$

-Middle:  $A_{st,mid} = 307.8761$

Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.00$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 246628.748$

$V_n$  ((22.5.1.1), ACI 318-14) = 246628.748

NOTE: In expression (22.5.1.1) 'V<sub>w</sub>' is replaced by 'V<sub>w</sub> + f<sub>v</sub>V<sub>f</sub>' where V<sub>f</sub> is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14:  $V_c = 79077.14$

= 1 (normal-weight concrete)

$f'_c = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w \cdot d) = 0.00628319$

$A_s$  (tension reinf.) = 603.1858

$b_w = 300.00$

$d = 320.00$

$V_u \cdot d / M_u < 1 = 0.22206992$

$M_u = 6.9042E+006$

$V_u = 4791.309$

From (11.5.4.8), ACI 318-14:  $V_s = 167551.608$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

$V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 318865.838$

End Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (a)

## Calculation No. 12

beam B1, Floor 1

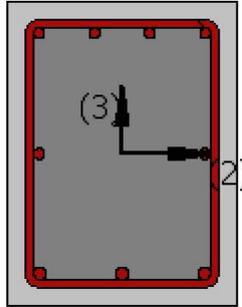
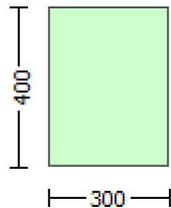
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 2740.264$

EDGE -B-

Shear Force,  $V_b = 2740.264$   
BOTH EDGES  
Axial Force,  $F = -189.411$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 603.1858$   
-Compression:  $As_c = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 603.1858$   
-Compression:  $As_{c,com} = 615.7522$   
-Middle:  $As_{c,mid} = 307.8761$

-----  
-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 0.39580698$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 112670.646$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0175E+008$   
 $Mu_{1+} = 9.9812E+007$ , 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  
 $Mu_{1-} = 1.0175E+008$ , 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  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0162E+008$   
 $Mu_{2+} = 9.9934E+007$ , 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  
 $Mu_{2-} = 1.0162E+008$ , 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  
and  
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$   
with  
 $V_1 = 2740.264$ , is the shear force acting at edge 1 for the the static loading combination  
 $V_2 = 2740.264$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 1.7580246E-005$   
 $Mu = 9.9812E+007$

-----  
with full section properties:

$b = 300.00$   
 $d = 357.00$   
 $d' = 42.00$   
 $v = 5.3592212E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $\phi_c$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_c$ :  $\phi_c^* = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_{cc}) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_c = 0.00553582$   
 $w_e$  (5.4c) = 0.00259035  
 $a_{se}$  ((5.4d), TBDY) = 0.15672608  
 $b_o = 240.00$   
 $h_o = 340.00$   
 $b_{i2} = 346400.00$   
 $\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00261799$   
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)

-----  
 $\phi_{sh,x}$  (5.4d) = 0.00349066  
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$   
No stirrups,  $n_s = 2.00$   
 $b_k = 300.00$

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06639156

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06777471

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.03388736

and confined core properties:

b = 240.00  
d = 327.00  
d' = 12.00

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09060316$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09249072$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04624536$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.18421297$$

$$Mu = MRc (4.14) = 9.9812E+007$$

$$u = su (4.1) = 1.7580246E-005$$

-----  
Calculation of ratio  $lb/ld$

-----  
Inadequate Lap Length with  $lb/ld = 0.30$   
-----  
-----

-----  
Calculation of  $Mu1$ -  
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7569691E-005$$

$$Mu = 1.0175E+008$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$we (5.4c) = 0.00259035$$

$$ase ((5.4d), TBDY) = 0.15672608$$

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$$

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)

$$psh,x (5.4d) = 0.00349066$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 300.00$$

$$psh,y (5.4d) = 0.00261799$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 389.0139$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 389.0139$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 389.0139$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.0675854$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06620611$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.0337927$$

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09220874$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09032693$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04610437$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.18600297$$

$$Mu = MRc (4.14) = 1.0175E+008$$

$$u = s_u(4.1) = 1.7569691E-005$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7539903E-005$$

$$\mu = 9.9934E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_c) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}((5.4d), \text{TB DY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

Expression ((5.4d), TB DY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal}((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_1_{nominal} = 0.08,$$

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TB DY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 389.0139$$

with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fs_2 = fs_2/1.2$ , 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  $fs_2 = fs = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_{yv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_{yv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = fs = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.06620611$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.0675854$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.0337927$   
 and confined core properties:  
 $b = 240.00$   
 $d = 328.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.09032693$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.09220874$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04610437$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18462058$   
 $Mu = MRc (4.14) = 9.9934E+007$   
 $u = su (4.1) = 1.7539903E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----  
 -----

Calculation of  $Mu_2$ -  
 -----  
 -----  
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7610316E-005$$

$$Mu = 1.0162E+008$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 5.3592212E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 466.8167$$

$$f_{y1} = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, f_{t1}, f_{y1}$ , it is considered characteristic value  $fs_1 = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = f_s = 389.0139$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 466.8167$$

$$f_{y2} = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, f_{t2}, f_{y2}$ , it is considered

characteristic value  $f_{s2} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s2} = f_s = 389.0139$

with  $E_{s2} = E_s = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$f_{y_v} = 389.0139$

$s_{u_v} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$s_{u_v} = 0.4 \cdot e_{s_{u_v,nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $e_{s_{u_v,nominal}} = 0.08$ ,

considering characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{s_{u_v,nominal}}$  and  $y_v, sh_v, ft_v, f_{y_v}$ , it is considered

characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s_v} = f_s = 389.0139$

with  $E_{s_v} = E_s = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06777471$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06639156$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.03388736$

and confined core properties:

b = 240.00

d = 327.00

d' = 12.00

f<sub>cc</sub> (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09249072$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09060316$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.04624536$

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) = 0.18560594

$\mu_u = M_{Rc}$  (4.14) = 1.0162E+008

u =  $s_u$  (4.1) = 1.7610316E-005

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 284660.584$   
-----

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 284660.584$

$V_{r1} = V_n$  ((22.5.1.1), ACI 318-14)  
-----

-----  
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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$

= 1 (normal-weight concrete)

$f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$p_w = A_s/(b_w \cdot d) = 0.00628319$

$A_s$  (tension reinf.) = 603.1858

$b_w = 300.00$

d = 320.00

$V_u \cdot d / \mu_u < 1 = 1.00$

Mu = 69262.055

Vu = 2740.264

From (11.5.4.8), ACI 318-14: Vs = 186169.943

Av = 157079.633

fy = 555.56

s = 150.00

Vs has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 366348.956

Calculation of Shear Strength at edge 2, Vr2 = 284660.584

Vr2 = Vn ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14: Vc = 98490.641

= 1 (normal-weight concrete)

fc' = 33.00, but  $fc'^{0.5} <= 8.3$  MPa (22.5.3.1, ACI 318-14)

pw = As/(bw\*d) = 0.00628319

As (tension reinf.) = 603.1858

bw = 300.00

d = 320.00

Vu\*d/Mu < 1 = 1.00

Mu = 69262.055

Vu = 2740.264

From (11.5.4.8), ACI 318-14: Vs = 186169.943

Av = 157079.633

fy = 555.56

s = 150.00

Vs has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 366348.956

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcars

Constant Properties

Knowledge Factor, = 0.90

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, fs = 1.25\*fsm = 694.45

#####

Section Height, H = 400.00

Section Width, W = 300.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.00

Element Length, L = 1850.00

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -8.6414578E-021$   
EDGE -B-  
Shear Force,  $V_b = 8.6414578E-021$   
BOTH EDGES  
Axial Force,  $F = -189.411$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 603.1858$   
-Compression:  $As_c = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 508.938$   
-Compression:  $As_{c,com} = 508.938$   
-Middle:  $As_{c,mid} = 508.938$

-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.37228966$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 71835.924$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 6.6448E+007$   
 $Mu_{1+} = 6.6448E+007$ , 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  
 $Mu_{1-} = 6.6448E+007$ , 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  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 6.6448E+007$   
 $Mu_{2+} = 6.6448E+007$ , 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  
 $Mu_{2-} = 6.6448E+007$ , 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  
and  
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$   
with  
 $V_1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination  
 $V_2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
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-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 2.4749691E-005$   
 $M_u = 6.6448E+007$

-----  
with full section properties:

$b = 400.00$   
 $d = 258.00$   
 $d' = 42.00$   
 $v = 5.5617499E-005$   
 $N = 189.411$   
 $f_c = 33.00$   
 $\phi_o$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_o) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.00553582$   
 $\phi_w$  (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of  $e_{sv\_nominal}$  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.

$\gamma_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05813483$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05813483$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05813483$

and confined core properties:

$b = 340.00$

$d = 228.00$

$d' = 12.00$

$f_{cc}$  (5A.2, TBDY) = 33.00

$cc$  (5A.5, TBDY) = 0.002

$c$  = confinement factor = 1.00

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.07739312$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07739312$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07739312$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su$  (4.9) = 0.19817337

$Mu = MRc$  (4.14) = 6.6448E+007

$u = su$  (4.1) = 2.4749691E-005

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----

-----  
Calculation of  $Mu_1$ -  
-----  
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 2.4749691E-005$

$Mu = 6.6448E+007$   
-----

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 5.5617499E-005$

$N = 189.411$

$f_c = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00553582$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$ase$  ((5.4d), TBDY) = 0.15672608

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

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)

-----  
 $psh,x$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$bk = 300.00$   
-----

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

-----  
s = 150.00  
fywe = 694.45  
fce = 33.00  
From ((5.A.5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00  
d = 228.00  
d' = 12.00  
fcc (5A.2, TBDY) = 33.00

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---->

$$su \text{ (4.9)} = 0.19817337$$

$$Mu = MRc \text{ (4.14)} = 6.6448E+007$$

$$u = su \text{ (4.1)} = 2.4749691E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$

-----  
Calculation of  $Mu_{2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$psh_{,min} = \text{Min}(psh_x, psh_y) = 0.00261799$$

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)

$$psh_x \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$psh_y \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$f_{y1} = 389.0139$   
 $s_{u1} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{u1} = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08$ ,  
 For calculation of  $e_{su1,nominal}$  and  $y_1, sh_1, ft_1, f_{y1}$ , it is considered  
 characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s1} = f_s = 389.0139$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $f_{y2} = 389.0139$   
 $s_{u2} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $s_{u2} = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su2,nominal} = 0.08$ ,  
 For calculation of  $e_{su2,nominal}$  and  $y_2, sh_2, ft_2, f_{y2}$ , it is considered  
 characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, f_{y2}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = f_s = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $f_{yv} = 389.0139$   
 $s_{uv} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv,nominal}$  and  $y_v, sh_v, ft_v, f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = f_s = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05813483$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05813483$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05813483$   
 and confined core properties:  
 $b = 340.00$   
 $d = 228.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $s_u (4.9) = 0.19817337$   
 $M_u = M_{Rc} (4.14) = 6.6448E+007$   
 $u = s_u (4.1) = 2.4749691E-005$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 2.4749691E-005$$

$$\mu_2 = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_2: \mu_2^* = \text{shear\_factor} * \text{Max}(\mu_2, c_o) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_2 = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07739312

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07739312

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07739312

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

v < vs,y2 - LHS eq.(4.5) is satisfied

---

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30  
-----  
-----  
-----

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 192957.075  
-----

-----  
Calculation of Shear Strength at edge 1, Vr1 = 192957.075

Vr1 = Vn ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/M_u < 1 = 0.00$   
 $M_u = 3.4215184E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
= 1 (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/M_u < 1 = 0.00$   
 $M_u = 3.4215797E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1  
At local axis: 3  
Integration Section: (a)  
Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Section Height,  $H = 400.00$   
Section Width,  $W = 300.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 1850.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -1.1438410E-010$   
Shear Force,  $V_2 = -4.6128812E-014$   
Shear Force,  $V_3 = -4791.309$   
Axial Force,  $F = -618.3078$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 603.1858$   
-Compression:  $A_{sc} = 923.6282$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 508.938$   
-Compression:  $A_{sc,com} = 508.938$   
-Middle:  $A_{st,mid} = 508.938$   
Mean Diameter of Tension Reinforcement,  $D_bL = 14.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.02206661$   
 $u = y + p = 0.02206661$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00206661$  ((4.29), Biskinis Phd)  
 $M_y = 4.8860E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 925.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 7.2898E+012$

#### Calculation of Yielding Moment $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 8.1958242E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 311.2112$   
 $d = 258.00$   
 $y = 0.26411015$   
 $A = 0.01481396$   
 $B = 0.00862083$   
with  $p_t = 0.00493157$   
 $p_c = 0.00493157$   
 $p_v = 0.00493157$   
 $N = 618.3078$   
 $b = 400.00$   
 $" = 0.1627907$   
 $y_{comp} = 3.2312585E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.26390049$

A = 0.01478109  
B = 0.00860158  
with Es = 200000.00

-----  
-----  
Calculation of ratio  $l_b/d$

-----  
Inadequate Lap Length with  $l_b/d = 0.30$

-----  
- Calculation of  $\rho$  -

-----  
From table 10-7:  $\rho = 0.02$

with:

- Condition iv occurred

Beam controlled by inadequate embedment into beam-column joint:  
( $l_b/d < 1$  and With Lapping in the Vicinity of the End Regions

- Condition i occurred

Beam controlled by flexure:  $V_p/V_o \leq 1$

shear control ratio  $V_p/V_o = 0.37228966$

- Transverse Reinforcement: NC

- Stirrup Spacing  $> d/3$

- Low ductility demand,  $\lambda / y < 2$  (table 10-6, ASCE 41-17)

= -7.0790750E-022

- Stirrup Spacing  $> d/2$

d = 258.00

s = 150.00

- Strength provided by hoops  $V_s < 3/4$ \*design Shear

$V_s = 139627.457$ , already given in calculation of shear control ratio

design Shear = 4.6128812E-014

- ( $\rho - \rho'$ )/ bal = -0.18222013

=  $A_{st}/(b_w*d) = 0.00584482$

Tension Reinf Area:  $A_{st} = 603.1858$

$\rho' = A_{sc}/(b_w*d) = 0.00894989$

Compression Reinf Area:  $A_{sc} = 923.6282$

From (B-1), ACI 318-11: bal = 0.01704017

$f_c = 33.00$

$f_y = 555.56$

From 10.2.7.3, ACI 318-11:  $\lambda = 0.65$

From fig R10.3.3, ACI 318-11 (Ence 454, too):  $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \lambda) = 0.51922877$

$y = 0.0027778$

-  $V/(b_w*d*f_c^{0.5}) = 9.3704152E-019$ , NOTE: units in lb & in

$b_w = 400.00$

-----  
End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (a)

-----  
**Calculation No. 13**

beam B1, Floor 1

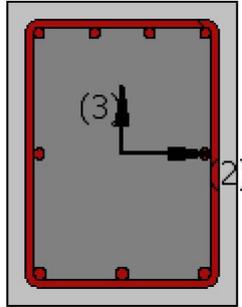
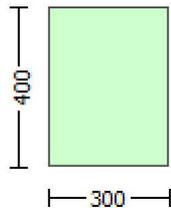
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\gamma = 0.90$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -1.1438410E-010$

Shear Force,  $V_a = -4.6128812E-014$

EDGE -B-

Bending Moment,  $M_b = 2.9032116E-011$

Shear Force,  $V_b = 4.6128812E-014$

BOTH EDGES

Axial Force,  $F = -618.3078$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 615.7522$   
-Compression:  $As_c = 911.0619$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{,ten} = 508.938$   
-Compression:  $As_{,com} = 508.938$   
-Middle:  $As_{,mid} = 508.938$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 14.66667$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 171047.78$   
 $V_n$  ((22.5.1.1), ACI 318-14) = 171047.78

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 (22.5.5.1), ACI 318-14:  $V_c = 76800.00$   
= 1 (normal-weight concrete)  
 $f_c' = 25.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = As/(b_w \cdot d) = 0.00641409$   
 $As$  (tension reinf.) = 615.7522  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u \cdot d / M_u < 1 = 0.00$   
 $M_u = 2.9032116E-011$   
 $V_u = 4.6128812E-014$

From (11.5.4.8), ACI 318-14:  $V_s = 94247.78$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 150.00$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 318865.838$

End Of Calculation of Shear Capacity for element: beam B1 of floor 1  
At local axis: 2  
Integration Section: (b)

## Calculation No. 14

beam B1, Floor 1

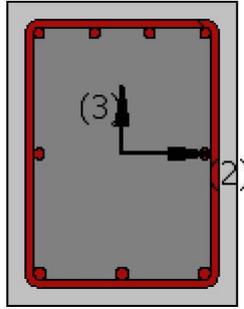
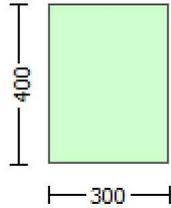
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcars

Constant Properties

-----  
 Knowledge Factor,  $\gamma = 0.90$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####  
 Section Height,  $H = 400.00$   
 Section Width,  $W = 300.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.00  
 Element Length,  $L = 1850.00$   
 Primary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
 No FRP Wrapping

-----  
 Stepwise Properties

-----  
 At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = 2740.264$   
 EDGE -B-  
 Shear Force,  $V_b = 2740.264$   
 BOTH EDGES  
 Axial Force,  $F = -189.411$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl,t} = 603.1858$   
 -Compression:  $A_{sl,c} = 923.6282$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl,ten} = 603.1858$   
 -Compression:  $A_{sl,com} = 615.7522$   
 -Middle:  $A_{sl,mid} = 307.8761$   
 -----  
 -----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.39580698$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 112670.646$   
with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 1.0175E+008$

$M_{u1+} = 9.9812E+007$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.0175E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 1.0162E+008$

$M_{u2+} = 9.9934E+007$ , 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

$M_{u2-} = 1.0162E+008$ , 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

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = 2740.264$ , is the shear force acting at edge 1 for the the static loading combination

$V_2 = 2740.264$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 1.7580246E-005$

$M_u = 9.9812E+007$

-----  
with full section properties:

$b = 300.00$

$d = 357.00$

$d' = 42.00$

$v = 5.3592212E-005$

$N = 189.411$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00553582$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x} , \phi_{sh,y}) = 0.00261799$

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)

-----  
 $\phi_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 300.00$

-----  
 $\phi_{sh,y}$  (5.4d) = 0.00261799

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 400.00$

-----  
 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $\phi_c = 0.002$

$\phi_c$  = confinement factor = 1.00

$\phi_{y1} = 0.00140044$

$\phi_{sh1} = 0.0044814$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 389.0139$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 389.0139$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 389.0139$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06639156$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06777471$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09060316$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09249072$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04624536$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.18421297$$

$$Mu = MRc (4.14) = 9.9812E+007$$

$$u = s_u(4.1) = 1.7580246E-005$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7569691E-005$$

$$\mu = 1.0175E+008$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } c_u = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}((5.4d), \text{TB DY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

Expression ((5.4d), TB DY) for  $p_{sh,min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal}((5.5), \text{TB DY}) = 0.032$$

From table 5A.1, TB DY:  $esu_1_{nominal} = 0.08$ ,

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TB DY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 389.0139$$

with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $fy_2 = 389.0139$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fs_2 = fs_2/1.2$ , 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  $fs_2 = fs = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $fy_v = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = fs = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.0675854$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.06620611$   
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.0337927$   
 and confined core properties:  
 $b = 240.00$   
 $d = 328.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09220874$   
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09032693$   
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.04610437$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18600297$   
 $Mu = MRc (4.14) = 1.0175E+008$   
 $u = su (4.1) = 1.7569691E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----

-----  
 Calculation of  $Mu_{2+}$   
 -----  
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7539903E-005$$

$$Mu = 9.9934E+007$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 5.3442513E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00553582$$

$$w_e(5.4c) = 0.00259035$$

$$a_{se}((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x}(5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y}(5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 466.8167$$

$$f_{y1} = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, f_{t1}, f_{y1}$ , it is considered  
characteristic value  $f_{s1} = f_s/1.2$ , from table 5.1, TBDY.

$$y_1, sh_1, f_{t1}, f_{y1}, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } f_{s1} = f_s = 389.0139$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 466.8167$$

$$f_{y2} = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, f_{t2}, f_{y2}$ , it is considered

characteristic value  $f_{s2} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s2} = f_s = 389.0139$

with  $E_{s2} = E_s = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$f_{y_v} = 389.0139$

$s_{u_v} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$s_{u_v} = 0.4 \cdot e_{s_{u_v,nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $e_{s_{u_v,nominal}} = 0.08$ ,

considering characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{s_{u_v,nominal}}$  and  $y_v, sh_v, ft_v, f_{y_v}$ , it is considered

characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s_v} = f_s = 389.0139$

with  $E_{s_v} = E_s = 200000.00$

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06620611$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0675854$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.0337927$

and confined core properties:

b = 240.00

d = 328.00

d' = 13.00

f<sub>cc</sub> (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 =  $As_{l,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09032693$

2 =  $As_{l,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09220874$

v =  $As_{l,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.04610437$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.18462058

Mu = MRc (4.14) = 9.9934E+007

u = su (4.1) = 1.7539903E-005

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----  
-----

-----  
Calculation of Mu2-  
-----  
-----  
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

u = 1.7610316E-005

Mu = 1.0162E+008

-----  
with full section properties:

b = 300.00

d = 357.00

d' = 42.00

v = 5.3592212E-005

N = 189.411

f<sub>c</sub> = 33.00

co (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00553582$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

-----  
 $p_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 300.00$

-----  
 $p_{sh,y}$  (5.4d) = 0.00261799

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 400.00$

-----  
 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_1 = fs = 389.0139$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 * esu_{2,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = fs = 389.0139$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = fs = 389.0139$

with  $Esv = Es = 200000.00$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06777471$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06639156$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$c =$  confinement factor = 1.00

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09249072$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09060316$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04624536$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

---

$v < vs,y2$  - LHS eq.(4.5) is satisfied

---

$$su (4.9) = 0.18560594$$

$$\text{Mu} = \text{MRc} (4.14) = 1.0162\text{E}+008$$

$$u = su (4.1) = 1.7610316\text{E}-005$$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 284660.584$

Calculation of Shear Strength at edge 1,  $Vr1 = 284660.584$

$Vr1 = Vn$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $Vc = 98490.641$

= 1 (normal-weight concrete)

$fc' = 33.00$ , but  $fc^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$pw = As/(bw*d) = 0.00628319$$

$As$  (tension reinf.) = 603.1858

$bw = 300.00$

$d = 320.00$

$$Vu*d/\text{Mu} < 1 = 1.00$$

$\text{Mu} = 69262.055$

$Vu = 2740.264$

From (11.5.4.8), ACI 318-14:  $Vs = 186169.943$

$Av = 157079.633$

$fy = 555.56$

$s = 150.00$

$Vs$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17, 10.3.4)

$Vf$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $Vs + Vf \leq 366348.956$

Calculation of Shear Strength at edge 2,  $Vr2 = 284660.584$

$Vr2 = Vn$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
= 1 (normal-weight concrete)  
 $f'_c = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
As (tension reinf.) = 603.1858  
bw = 300.00  
d = 320.00  
 $V_u*d/M_u < 1 = 1.00$   
Mu = 69262.055  
Vu = 2740.264  
From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
Av = 157079.633  
fy = 555.56  
s = 150.00  
Vs has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

-----  
End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcars

#### Constant Properties

-----  
Knowledge Factor, = 0.90  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength,  $f_s = 1.25*f_{sm} = 694.45$   
#####  
Section Height, H = 400.00  
Section Width, W = 300.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 1850.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
No FRP Wrapping

#### Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = -8.6414578E-021  
EDGE -B-  
Shear Force, Vb = 8.6414578E-021

BOTH EDGES

Axial Force,  $F = -189.411$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 603.1858$

-Compression:  $As_c = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{,ten} = 508.938$

-Compression:  $As_{,com} = 508.938$

-Middle:  $As_{,mid} = 508.938$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.37228966$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 71835.924$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 6.6448E+007$

$Mu_{1+} = 6.6448E+007$ , 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

$Mu_{1-} = 6.6448E+007$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 6.6448E+007$

$Mu_{2+} = 6.6448E+007$ , 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

$Mu_{2-} = 6.6448E+007$ , 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

and

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

with

$V_1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination

$V_2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.4749691E-005$

$Mu = 6.6448E+007$

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 5.5617499E-005$

$N = 189.411$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00553582$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00553582$

$w_e$  (5.4c) = 0.00259035

$a_{se}$  ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$bi_2 = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

$p_{sh,x}$  (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 300.00$

psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 400.00

-----  
s = 150.00  
fywe = 694.45  
fce = 33.00  
From ((5.A.5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00  
d = 228.00  
d' = 12.00  
fcc (5A.2, TBDY) = 33.00

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su \text{ (4.9)} = 0.19817337$$

$$Mu = MRc \text{ (4.14)} = 6.6448E+007$$

$$u = su \text{ (4.1)} = 2.4749691E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu1$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$f_{y1} = 389.0139$   
 $s_{u1} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{u1} = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{s1\_nominal} = 0.08$ ,  
 For calculation of  $e_{s1\_nominal}$  and  $y_1, sh_1, ft_1, f_{y1}$ , it is considered  
 characteristic value  $f_{s1} = f_s/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s1} = f_s = 389.0139$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 466.8167$   
 $f_{y2} = 389.0139$   
 $s_{u2} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $s_{u2} = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{s2\_nominal} = 0.08$ ,  
 For calculation of  $e_{s2\_nominal}$  and  $y_2, sh_2, ft_2, f_{y2}$ , it is considered  
 characteristic value  $f_{s2} = f_s/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, f_{y2}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = f_s = 389.0139$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 466.8167$   
 $f_{yv} = 389.0139$   
 $s_{uv} = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $y_v, sh_v, ft_v, f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = f_s = 389.0139$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05813483$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05813483$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05813483$   
 and confined core properties:  
 $b = 340.00$   
 $d = 228.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $s_u (4.9) = 0.19817337$   
 $M_u = M_{Rc} (4.14) = 6.6448E+007$   
 $u = s_u (4.1) = 2.4749691E-005$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 2.4749691E-005$$

$$\mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07739312

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07739312

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07739312

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

v < vs,y2 - LHS eq.(4.5) is satisfied

---

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

-----  
Calculation of ratio lb/ld

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Inadequate Lap Length with lb/ld = 0.30  
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Calculation of Mu2-  
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-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 2.4749691E-005  
Mu = 6.6448E+007

-----  
with full section properties:

b = 400.00  
d = 258.00  
d' = 42.00  
v = 5.5617499E-005  
N = 189.411  
fc = 33.00  
co (5A.5, TBDY) = 0.002  
Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00553582  
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY: cu = 0.00553582  
we (5.4c) = 0.00259035  
ase ((5.4d), TBDY) = 0.15672608  
bo = 240.00  
ho = 340.00  
bi2 = 346400.00  
psh,min = Min(psh,x , psh,y) = 0.00261799  
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 (5.4d) = 0.00349066  
Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 300.00

-----  
psh,y (5.4d) = 0.00261799  
Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 400.00

-----  
s = 150.00  
fywe = 694.45  
fce = 33.00  
From ((5.A5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00  
y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/d = 0.30  
su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032  
From table 5A.1, TBDY: esu1\_nominal = 0.08,  
For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.  
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.  
with fs1 = fs = 389.0139  
with Es1 = Es = 200000.00  
y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
su2 = 0.00512  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min = lb/lb,min = 0.30  
su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032  
From table 5A.1, TBDY: esu2\_nominal = 0.08,  
For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = fs = 389.0139$

with  $Es2 = Es = 200000.00$

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 466.8167$

$fyv = 389.0139$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lou, \min = lb/ld = 0.30$

$suv = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered

characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = fs = 389.0139$

with  $Es = Es = 200000.00$

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05813483$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05813483$

v =  $Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05813483$

and confined core properties:

$b = 340.00$

$d = 228.00$

$d' = 12.00$

$fcc (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

c = confinement factor = 1.00

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.07739312$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.07739312$

v =  $Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07739312$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs, y2$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.19817337$

$Mu = MRc (4.14) = 6.6448E+007$

$u = su (4.1) = 2.4749691E-005$

-----  
Calculation of ratio  $lb/ld$

-----  
Inadequate Lap Length with  $lb/ld = 0.30$   
-----  
-----  
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-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 192957.075$   
-----

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 192957.075$

$Vr1 = Vn ((22.5.1.1), ACI 318-14)$   
-----

NOTE: In expression (22.5.1.1) ' $Vw$ ' is replaced by ' $Vw + f \cdot Vf$ '  
where  $Vf$  is the contribution of FRPs (11.3), ACI 440).  
-----

From Table (22.5.5.1), ACI 318-14:  $Vc = 88236.482$

= 1 (normal-weight concrete)

$fc' = 33.00$ , but  $fc^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$pw = As / (bw \cdot d) = 0.00628319$

$As$  (tension reinf.) = 603.1858

$bw = 400.00$

$d = 240.00$

$Vu \cdot d / Mu < 1 = 0.00$

$Mu = 3.4215184E-013$

$$V_u = 8.6414578E-021$$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.75$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 366348.956$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$

$$V_{r2} = V_n ((22.5.1.1), ACI 318-14)$$

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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$

= 1 (normal-weight concrete)

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w \cdot d) = 0.00628319$$

$$A_s (\text{tension reinf.}) = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u \cdot d / M_u < 1 = 0.00$$

$$M_u = 3.4215797E-013$$

$$V_u = 8.6414578E-021$$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.75$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 366348.956$$

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor, = 0.90

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b / l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = 7.0292E+006$   
Shear Force,  $V2 = 4.6128812E-014$   
Shear Force,  $V3 = 10271.838$   
Axial Force,  $F = -618.3078$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 615.7522$   
-Compression:  $As_c = 911.0619$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 615.7522$   
-Compression:  $As_{c,com} = 603.1858$   
-Middle:  $As_{c,mid} = 307.8761$   
Mean Diameter of Tension Reinforcement,  $Db_L = 14.00$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.02126874$   
 $u = y + p = 0.02126874$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00126874$  ((4.29), Biskinis Phd)  
 $M_y = 7.2083E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) =  $684.3158$   
From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 1.2960E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.8363338E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/d)^{2/3}) = 311.2112$   
 $d = 358.00$   
 $y = 0.25526458$   
 $A = 0.01423464$   
 $B = 0.00803181$   
with  $p_t = 0.00573326$   
 $p_c = 0.00561626$   
 $p_v = 0.00286663$   
 $N = 618.3078$   
 $b = 300.00$   
 $" = 0.12011173$   
 $y_{comp} = 2.4094792E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.25505004$   
 $A = 0.01420306$   
 $B = 0.00801331$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

- Calculation of  $p$  -

From table 10-7:  $p = 0.02$

with:

- Condition iv occurred  
Beam controlled by inadequate embedment into beam-column joint:  
( $b/d < 1$  and With Lapping in the Vicinity of the End Regions)
- Condition i occurred  
Beam controlled by flexure:  $V_p/V_o \leq 1$   
shear control ratio  $V_p/V_o = 0.39580698$
- Transverse Reinforcement: NC
- Stirrup Spacing  $> d/3$
- Low ductility demand,  $\lambda / \gamma < 2$  (table 10-6, ASCE 41-17)  
 $= 2.9053636E-005$
- Stirrup Spacing  $\leq d/2$   
 $d = 358.00$   
 $s = 150.00$
- Strength provided by hoops  $V_s < 3/4 * \text{design Shear}$   
 $V_s = 186169.943$ , already given in calculation of shear control ratio  
design Shear = 10271.838
- ( $\rho' - \rho_s$ )/  $\rho_{bal} = -0.16136132$   
 $= A_{st}/(b_w * d) = 0.00573326$   
Tension Reinf Area:  $A_{st} = 615.7522$   
 $\rho' = A_{sc}/(b_w * d) = 0.00848289$   
Compression Reinf Area:  $A_{sc} = 911.0619$
- From (B-1), ACI 318-11:  $\rho_{bal} = 0.01704017$   
 $f_c = 33.00$   
 $f_y = 555.56$   
From 10.2.7.3, ACI 318-11:  $\lambda = 1 = 0.65$   
From fig R10.3.3, ACI 318-11 (Ence 454, too):  $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \lambda) = 0.51922877$   
 $\gamma = 0.0027778$
- $V/(b_w * d * f_c^{0.5}) = 0.20049804$ , NOTE: units in lb & in  
 $b_w = 300.00$

-----  
End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (b)  
-----

## Calculation No. 15

beam B1, Floor 1

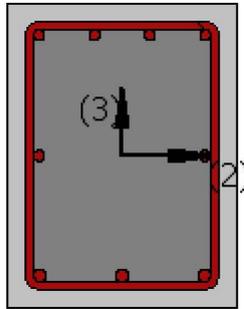
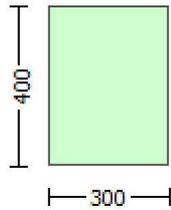
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 6.9042E+006$

Shear Force,  $V_a = -4791.309$

EDGE -B-

Bending Moment,  $M_b = 7.0292E+006$

Shear Force,  $V_b = 10271.838$

BOTH EDGES

Axial Force,  $F = -618.3078$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_{t1} = 615.7522$

-Compression:  $As_{c1} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 615.7522$

-Compression:  $As_{l,com} = 603.1858$

-Middle:  $As_{l,mid} = 307.8761$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 14.00$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 249246.558$

$V_n$  ((22.5.1.1), ACI 318-14) = 249246.558

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 (22.5.5.1), ACI 318-14:  $V_c = 81694.95$   
= 1 (normal-weight concrete)  
 $f'_c = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00641409$   
 $A_s$  (tension reinf.) = 615.7522  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/\mu < 1 = 0.46762033$   
 $\mu = 7.0292E+006$   
 $V_u = 10271.838$   
From (11.5.4.8), ACI 318-14:  $V_s = 167551.608$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 318865.838$

End Of Calculation of Shear Capacity for element: beam B1 of floor 1  
At local axis: 3  
Integration Section: (b)

## Calculation No. 16

beam B1, Floor 1

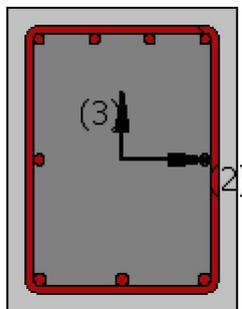
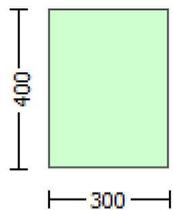
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 3  
(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor,  $\phi = 0.90$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 * f_{sm} = 694.45$

#####

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = 2740.264$

EDGE -B-

Shear Force,  $V_b = 2740.264$

BOTH EDGES

Axial Force,  $F = -189.411$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 603.1858$

-Compression:  $A_{sl,c} = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 603.1858$

-Compression:  $A_{sl,com} = 615.7522$

-Middle:  $A_{sl,mid} = 307.8761$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.39580698$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u * l_n / 2 = 112670.646$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.0175E+008$

$M_{u1+} = 9.9812E+007$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.0175E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.0162E+008$

$M_{u2+} = 9.9934E+007$ , 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

$M_{u2-} = 1.0162E+008$ , 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

and

$\pm w_u * l_n = (|V_1| + |V_2|) / 2$

with

V1 = 2740.264, is the shear force acting at edge 1 for the the static loading combination  
V2 = 2740.264, is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of Mu1+  
-----

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.7580246E-005$$

$$Mu = 9.9812E+007$$

-----  
with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 5.3592212E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

-----  
$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

-----  
$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

-----  
$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 389.0139$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fs_v = fs_v/1.2$ , 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  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_v = fs = 389.0139$$

$$\text{with } Es_v = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.06639156$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.06777471$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.03388736$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.09060316$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.09249072$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.04624536$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.18421297$$

$$Mu = MRc (4.14) = 9.9812E+007$$

$$u = su (4.1) = 1.7580246E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
-----  
-----

-----  
Calculation of  $Mu_1$ -  
-----  
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7569691E-005$$

$$Mu = 1.0175E+008$$

-----  
with full section properties:

b = 300.00  
d = 358.00  
d' = 43.00  
v = 5.3442513E-005  
N = 189.411

fc = 33.00  
co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$   
The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00553582$

we (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 =  $0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu1\_nominal} = 0.08$ ,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value  $\text{fsy1} = \text{fs1}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $\text{fs1} = \text{fs} = 389.0139$

with  $\text{Es1} = \text{Es} = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 =  $0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu2\_nominal} = 0.08$ ,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value  $\text{fsy2} = \text{fs2}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $\text{fs2} = \text{fs} = 389.0139$

with  $\text{Es2} = \text{Es} = 200000.00$

yv = 0.00140044

$shv = 0.0044814$   
 $ftv = 466.8167$   
 $fyv = 389.0139$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 389.0139$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.0675854$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.06620611$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.0337927$   
 and confined core properties:  
 $b = 240.00$   
 $d = 328.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c =$  confinement factor  $= 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.09220874$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.09032693$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04610437$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.18600297$   
 $Mu = MRc (4.14) = 1.0175E+008$   
 $u = su (4.1) = 1.7569691E-005$

-----  
 Calculation of ratio  $lb/ld$   
 -----

Inadequate Lap Length with  $lb/ld = 0.30$   
 -----  
 -----  
 -----

Calculation of  $Mu2+$   
 -----  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7539903E-005$   
 $Mu = 9.9934E+007$   
 -----

with full section properties:

$b = 300.00$   
 $d = 358.00$   
 $d' = 43.00$   
 $v = 5.3442513E-005$   
 $N = 189.411$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max( cu, cc) = 0.00553582$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00553582$   
 $we (5.4c) = 0.00259035$   
 $ase ((5.4d), TBDY) = 0.15672608$   
 $bo = 240.00$

ho = 340.00

bi2 = 346400.00

psh,min = Min(psh,x , psh,y) = 0.00261799

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

-----  
psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

-----  
s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y2, sh2,ft2,fy2, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = f_s = 389.0139$

with  $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06620611$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0675854$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.0337927$

and confined core properties:

$b = 240.00$

$d = 328.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 33.00$

$cc \text{ (5A.5, TBDY)} = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09032693$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09220874$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04610437$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su \text{ (4.9)} = 0.18462058$

$Mu = MRc \text{ (4.14)} = 9.9934E+007$

$u = su \text{ (4.1)} = 1.7539903E-005$

-----  
Calculation of ratio  $l_b/d$

-----  
Inadequate Lap Length with  $l_b/d = 0.30$

-----  
Calculation of  $Mu_2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.7610316E-005$

$Mu = 1.0162E+008$

-----  
with full section properties:

$b = 300.00$

$d = 357.00$

$d' = 42.00$

$v = 5.3592212E-005$

$N = 189.411$

$f_c = 33.00$

$co \text{ (5A.5, TBDY)} = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00553582$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e \text{ (5.4c)} = 0.00259035$

$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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)

-----  
 $p_{sh,x} \text{ (5.4d)} = 0.00349066$

$A_{sh} = A_{stir} \cdot ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 300.00$

-----  
 $p_{sh,y} \text{ (5.4d)} = 0.00261799$

$A_{sh} = A_{stir} \cdot ns = 78.53982$

No stirrups, ns = 2.00  
bk = 400.00

s = 150.00  
fywe = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 466.8167  
fy1 = 389.0139  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044  
sh2 = 0.0044814  
ft2 = 466.8167  
fy2 = 389.0139  
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044  
shv = 0.0044814  
ftv = 466.8167  
fyv = 389.0139  
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.06777471

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.06639156

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.03388736

and confined core properties:

b = 240.00  
d = 327.00  
d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.09249072$$

$$2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.09060316$$

$$v = A_{s1,mid}/(b*d)*(f_{sv}/f_c) = 0.04624536$$

Case/Assumption: Unconfined full section - Steel rupture  
satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

$$s_u(4.9) = 0.18560594$$

$$\mu_u = M_{Rc}(4.14) = 1.0162E+008$$

$$u = s_u(4.1) = 1.7610316E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 284660.584$

Calculation of Shear Strength at edge 1,  $V_{r1} = 284660.584$   
 $V_{r1} = V_n$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
= 1 (normal-weight concrete)  
 $f'_c = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/\mu_u < 1 = 1.00$   
 $\mu_u = 69262.055$   
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

Calculation of Shear Strength at edge 2,  $V_{r2} = 284660.584$   
 $V_{r2} = V_n$  ((22.5.1.1), ACI 318-14)

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 (22.5.5.1), ACI 318-14:  $V_c = 98490.641$   
= 1 (normal-weight concrete)  
 $f'_c = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $\rho_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 300.00$   
 $d = 320.00$   
 $V_u*d/\mu_u < 1 = 1.00$   
 $\mu_u = 69262.055$   
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14:  $V_s = 186169.943$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by 1 ( $s < d/2$ , according to ASCE 41-17,10.3.4)

Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 366348.956

End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcars

Constant Properties

Knowledge Factor, = 0.90  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 33.00  
New material of Primary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00

#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength, fs = 1.25\*fsm = 694.45

#####  
Section Height, H = 400.00  
Section Width, W = 300.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 1850.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with lo/lo,min = 0.30  
No FRP Wrapping

Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force, Va = -8.6414578E-021  
EDGE -B-  
Shear Force, Vb = 8.6414578E-021  
BOTH EDGES  
Axial Force, F = -189.411  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: Aslt = 603.1858  
-Compression: Aslc = 923.6282  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension: Asl,ten = 508.938  
-Compression: Asl,com = 508.938  
-Middle: Asl,mid = 508.938

Calculation of Shear Capacity ratio , Ve/Vr = 0.37228966  
Member Controlled by Flexure (Ve/Vr < 1)  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln ± wu\*ln/2 = 71835.924  
with  
Mpr1 = Max(Mu1+ , Mu1-) = 6.6448E+007

$Mu_{1+} = 6.6448E+007$ , 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

$Mu_{1-} = 6.6448E+007$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr2 = \text{Max}(Mu_{2+}, Mu_{2-}) = 6.6448E+007$

$Mu_{2+} = 6.6448E+007$ , 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

$Mu_{2-} = 6.6448E+007$ , 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

and

$\pm wu*ln = (|V1| + |V2|)/2$

with

$V1 = -8.6414578E-021$ , is the shear force acting at edge 1 for the the static loading combination

$V2 = 8.6414578E-021$ , is the shear force acting at edge 2 for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 2.4749691E-005$

$Mu = 6.6448E+007$   
-----

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 5.5617499E-005$

$N = 189.411$

$fc = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00553582$

$w_e (5.4c) = 0.00259035$

$a_{se} ((5.4d), TBDY) = 0.15672608$

$bo = 240.00$

$ho = 340.00$

$bi2 = 346400.00$

$psh, \text{min} = \text{Min}(psh, x, psh, y) = 0.00261799$

Expression ((5.4d), TBDY) for  $psh, \text{min}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh, x (5.4d) = 0.00349066$

$A_{sh} = A_{stir} * ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 300.00$   
-----

$psh, y (5.4d) = 0.00261799$

$A_{sh} = A_{stir} * ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 400.00$   
-----

$s = 150.00$

$fyw_e = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 466.8167$

$fy1 = 389.0139$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$s_u1 = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{s1\_nominal} = 0.08$ ,

For calculation of  $e_{s1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_{s1}/1.2$ , 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.

$$\text{with } f_{s1} = f_s = 389.0139$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$s_u2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{s2\_nominal} = 0.08$ ,

For calculation of  $e_{s2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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.

$$\text{with } f_{s2} = f_s = 389.0139$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{u,v} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$s_{u,v} = 0.4 * e_{s_{u,v}}\_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{s_{u,v}}\_{nominal} = 0.08$ ,

considering characteristic value  $f_{s_{y,v}} = f_{s_{v}}/1.2$ , from table 5.1, TBDY  
For calculation of  $e_{s_{u,v}}\_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $f_{s_{y,v}} = f_{s_{v}}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_{v}} = f_s = 389.0139$$

$$\text{with } E_{s_{v}} = E_s = 200000.00$$

$$1 = A_{s_{l,ten}} / (b * d) * (f_{s1} / f_c) = 0.05813483$$

$$2 = A_{s_{l,com}} / (b * d) * (f_{s2} / f_c) = 0.05813483$$

$$v = A_{s_{l,mid}} / (b * d) * (f_{s_{v}} / f_c) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s_{l,ten}} / (b * d) * (f_{s1} / f_c) = 0.07739312$$

$$2 = A_{s_{l,com}} / (b * d) * (f_{s2} / f_c) = 0.07739312$$

$$v = A_{s_{l,mid}} / (b * d) * (f_{s_{v}} / f_c) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---

$$s_u (4.9) = 0.19817337$$

$$\mu = M_{Rc} (4.14) = 6.6448E+007$$

$$u = s_u (4.1) = 2.4749691E-005$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00553582$$

$$w_e \text{ (5.4c)} = 0.00259035$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.05813483

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.05813483

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05813483

and confined core properties:

b = 340.00

d = 228.00

d' = 12.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07739312

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07739312

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07739312

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.19817337

Mu = MRc (4.14) = 6.6448E+007

u = su (4.1) = 2.4749691E-005

-----  
Calculation of ratio lb/ld

-----  
Inadequate Lap Length with lb/ld = 0.30  
-----  
-----

-----  
Calculation of Mu2+  
-----  
-----

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 2.4749691E-005

Mu = 6.6448E+007  
-----

with full section properties:

b = 400.00

d = 258.00  
d' = 42.00  
v = 5.5617499E-005  
N = 189.411

fc = 33.00  
co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00553582$

we (5.4c) = 0.00259035

ase ((5.4d), TBDY) = 0.15672608

bo = 240.00

ho = 340.00

bi2 = 346400.00

psh,min =  $\text{Min}(psh,x, psh,y) = 0.00261799$

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 (5.4d) = 0.00349066

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 300.00

-----  
psh,y (5.4d) = 0.00261799

Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00

bk = 400.00

-----  
s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/d = 0.30

su1 =  $0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu1\_nominal} = 0.08$ ,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value  $\text{fsy1} = \text{fs1}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 =  $0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu2\_nominal} = 0.08$ ,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value  $\text{fsy2} = \text{fs2}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 389.0139$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.05813483$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.05813483$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.05813483$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.07739312$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.07739312$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07739312$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs, y2$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.19817337$$

$$Mu = MRc (4.14) = 6.6448E+007$$

$$u = su (4.1) = 2.4749691E-005$$

Calculation of ratio  $lb/d$

Inadequate Lap Length with  $lb/d = 0.30$

Calculation of  $Mu2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 2.4749691E-005$$

$$Mu = 6.6448E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 5.5617499E-005$$

$$N = 189.411$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00553582$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00553582$$

$$we (5.4c) = 0.00259035$$

$$ase ((5.4d), TBDY) = 0.15672608$$

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$$

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)

$$psh,x (5.4d) = 0.00349066$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 300.00$$

$$psh,y (5.4d) = 0.00261799$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/l_d = 0.30$$

$$su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 389.0139$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/l_b,min = 0.30$$

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 389.0139$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lou,min = lb/l_d = 0.30$$

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = f_s = 389.0139$   
with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05813483$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05813483$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05813483$

and confined core properties:

$b = 340.00$   
 $d = 228.00$   
 $d' = 12.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07739312$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07739312$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07739312$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->  
 $su (4.9) = 0.19817337$   
 $\mu_u = MR_c (4.14) = 6.6448E+007$   
 $u = su (4.1) = 2.4749691E-005$

-----  
Calculation of ratio  $l_b/d$

-----  
Inadequate Lap Length with  $l_b/d = 0.30$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 192957.075$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 192957.075$   
 $V_{r1} = V_n ((22.5.1.1), ACI 318-14)$

-----  
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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
 $= 1$  (normal-weight concrete)  
 $f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $p_w = A_s/(b_w*d) = 0.00628319$   
 $A_s$  (tension reinf.) = 603.1858  
 $b_w = 400.00$   
 $d = 240.00$   
 $V_u*d/\mu_u < 1 = 0.00$   
 $\mu_u = 3.4215184E-013$   
 $V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 150.00$   
 $V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17, 10.3.4)  
 $2(1-s/d) = 0.75$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 192957.075$   
 $V_{r2} = V_n ((22.5.1.1), ACI 318-14)$

-----  
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 (22.5.5.1), ACI 318-14:  $V_c = 88236.482$   
 $= 1$  (normal-weight concrete)

$f_c' = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$\rho_w = A_s / (b_w \cdot d) = 0.00628319$

$A_s$  (tension reinf.) = 603.1858

$b_w = 400.00$

$d = 240.00$

$V_u \cdot d / M_u < 1 = 0.00$

$M_u = 3.4215797E-013$

$V_u = 8.6414578E-021$

From (11.5.4.8), ACI 318-14:  $V_s = 104720.593$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

$V_s$  has been multiplied by  $2(1-s/d)$  ( $s > d/2$ , according to ASCE 41-17, 10.3.4)

$2(1-s/d) = 0.75$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 366348.956$

-----  
End Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1

At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcars

Constant Properties

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Knowledge Factor,  $\gamma = 0.90$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 400.00$

Section Width,  $W = 300.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 1850.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b / l_d = 0.30$

No FRP Wrapping

-----  
Stepwise Properties

Bending Moment,  $M = 2.9032116E-011$

Shear Force,  $V_2 = 4.6128812E-014$

Shear Force,  $V_3 = 10271.838$

Axial Force,  $F = -618.3078$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 615.7522$

-Compression:  $A_{sl,c} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 508.938$

-Compression:  $A_{sl,com} = 508.938$

-Middle:  $A_{sl,mid} = 508.938$

Mean Diameter of Tension Reinforcement,  $DbL = 14.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.02206661$   
 $u = y + p = 0.02206661$

-----  
- Calculation of  $y$  -  
-----

$y = (M_y * L_s / 3) / E_{eff} = 0.00206661$  ((4.29), Biskinis Phd))  
 $M_y = 4.8860E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 925.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = 0.3 * E_c * I_g = 7.2898E+012$

-----  
Calculation of Yielding Moment  $M_y$   
-----

Calculation of  $y$  and  $M_y$  according to Annex 7 -  
-----

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 8.1958242E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/d)^{2/3}) = 311.2112$   
 $d = 258.00$   
 $y = 0.26411015$   
 $A = 0.01481396$   
 $B = 0.00862083$   
with  $p_t = 0.00493157$   
 $p_c = 0.00493157$   
 $p_v = 0.00493157$   
 $N = 618.3078$   
 $b = 400.00$   
 $" = 0.1627907$   
 $y_{comp} = 3.2312585E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.26390049$   
 $A = 0.01478109$   
 $B = 0.00860158$   
with  $E_s = 200000.00$

-----  
Calculation of ratio  $l_b/d$   
-----

Inadequate Lap Length with  $l_b/d = 0.30$   
-----

- Calculation of  $p$  -  
-----

From table 10-7:  $p = 0.02$

with:

- Condition iv occurred  
Beam controlled by inadequate embedment into beam-column joint:  
( $l_b/d < 1$  and With Lapping in the Vicinity of the End Regions)
- Condition i occurred  
Beam controlled by flexure:  $V_p/V_o \leq 1$   
shear control ratio  $V_p/V_o = 0.37228966$
- Transverse Reinforcement: NC
- Stirrup Spacing  $> d/3$
- Low ductility demand,  $\lambda / y < 2$  (table 10-6, ASCE 41-17)  
=  $-1.0067817E-021$
- Stirrup Spacing  $> d/2$   
 $d = 258.00$   
 $s = 150.00$
- Strength provided by hoops  $V_s < 3/4 * \text{design Shear}$   
 $V_s = 139627.457$ , already given in calculation of shear control ratio  
design Shear =  $4.6128812E-014$

- ( - ')/ bal = -0.16792835  
= Aslt/(bw\*d) = 0.00596659  
Tension Reinf Area: Aslt = 615.7522  
' = Aslc/(bw\*d) = 0.00882812  
Compression Reinf Area: Aslc = 911.0619  
From (B-1), ACI 318-11: bal = 0.01704017  
fc = 33.00  
fy = 555.56  
From 10.2.7.3, ACI 318-11: 1 = 0.65  
From fig R10.3.3, ACI 318-11 (Ence 454, too):  $87000/(87000+fy) = cb/dt = 0.003/(0.003+ y) = 0.51922877$   
y = 0.0027778  
-  $V/(bw*d*fc^{0.5}) = 9.3704152E-019$ , NOTE: units in lb & in  
bw = 400.00

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End Of Calculation of Chord Rotation Capacity for element: beam B1 of floor 1  
At local axis: 3  
Integration Section: (b)  
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