

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

beam B1, Floor 1

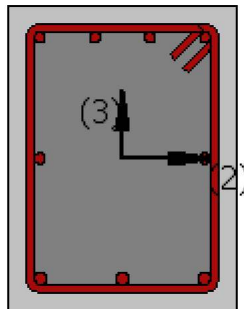
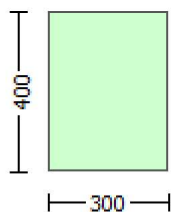
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = 2.8524885E-012$
Shear Force, $V_a = -7.9210123E-015$
EDGE -B-
Bending Moment, $M_b = -1.7513979E-011$
Shear Force, $V_b = 7.9210123E-015$
BOTH EDGES
Axial Force, $F = -506.3875$
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: $As_{mid} = 508.938$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = *V_n = 116312.49$
 $V_n ((22.5.1.1), ACI 318-14) = 136838.224$

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: $V_c = 61440.00$
 $= 1$ (normal-weight concrete)
 $f'_c = 16.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $\rho_w = As/(b_w*d) = 0.00628319$
 As (tension reinf.) = 603.1858
 $b_w = 400.00$
 $d = 240.00$
 $V_u*d/M_u < 1 = 0.00$
 $M_u = 2.8524885E-012$
 $V_u = 7.9210123E-015$
From (11.5.4.8), ACI 318-14: $V_s = 75398.224$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 150.00$
 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: $V_s + V_f \leq 255092.67$

End Of Calculation of Shear Capacity for element: beam B1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

beam B1, Floor 1

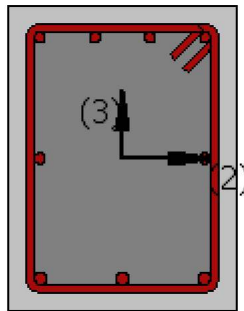
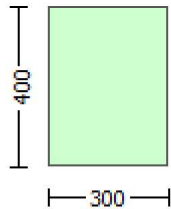
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\gamma = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

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Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

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Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$

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: $As_{l,com} = 615.7522$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.40051388$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.1931E+007$

$Mu_{1+} = 8.0426E+007$, 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

$Mu_{1-} = 8.1931E+007$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 8.1848E+007$

$Mu_{2+} = 8.0508E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 8.1848E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

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 static loading combination

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

Calculation of Mu_{1+}

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

$\phi_u = 1.7898746E-005$

$M_u = 8.0426E+007$

with full section properties:

$b = 300.00$

$d = 357.00$

$d' = 42.00$

$v = 0.00010459$

$N = 224.0408$

$f_c = 20.00$

ϕ_o (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_o) = 0.00777035$

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

From (5.4b), TBDY: $\phi_u = 0.00777035$

w_e (5.4c) = 0.01139744

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

$b_o = 240.00$

$h_o = 340.00$

$bi_2 = 346400.00$

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

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 300.00$$

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From } ((5A5), \text{TB DY}), \text{TB DY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y1 = 0.0012967$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4504$$

$$fy1 = 311.2087$$

$$su1 = 0.00512$$

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

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

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

$$\text{From table 5A.1, TB DY: } esu1_nominal = 0.08,$$

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

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

$$\text{with } fs1 = fs = 311.2087$$

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

$$\text{From table 5A.1, TB DY: } esu2_nominal = 0.08,$$

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

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

$$\text{with } fs2 = fs = 311.2087$$

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

$$suv = 0.4*esuv_nominal ((5.5), \text{TB DY}) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 311.2087$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.08763615$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08946191$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04473095$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 21.84352$$

$$cc (5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11959521$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12208678$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.06104339$$

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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$$s_u (4.9) = 0.19872953$$

$$M_u = M_{Rc} (4.14) = 8.0426E+007$$

$$u = s_u (4.1) = 1.7898746E-005$$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

Calculation of M_{u1} -

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

$$u = 1.7900352E-005$$

$$M_u = 8.1931E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, cc) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00777035$$

$$\phi_{we} (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$
 $ft1 = 373.4504$
 $fy1 = 311.2087$
 $su1 = 0.00512$
 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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 311.2087$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0012967$
 $sh2 = 0.0044814$
 $ft2 = 373.4504$
 $fy2 = 311.2087$
 $su2 = 0.00512$
 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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 311.2087$
 with $Es2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.08921201$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.08739136$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.04460601$
 and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.12171456$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.11923059$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.06085728$
 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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$$s_u(4.9) = 0.20103941$$

$$\mu_u = M_{Rc}(4.14) = 8.1931E+007$$

$$u = s_u(4.1) = 1.7900352E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2+}

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

$$u = 1.7861306E-005$$

$$\mu_u = 8.0508E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \alpha_c = 0.00777035$$

$$\alpha_{we}(5.4c) = 0.01139744$$

$$\alpha_{ase}((5.4d), \text{TB DY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal}((5.5), \text{TB DY}) = 0.032$$

From table 5A.1, TB DY: $s_{u1_nominal} = 0.08$,

For calculation of $s_{u1_nominal}$ and y_1 , sh_1 , ft_1 , fy_1 , it is considered characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TB DY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 311.2087$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0012967$
 $sh2 = 0.0044814$
 $ft2 = 373.4504$
 $fy2 = 311.2087$
 $su2 = 0.00512$
 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
 $lo/lou, min = lb/lb, min = 0.30$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 311.2087$
 with $Es2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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
 $lo/lou, min = lb/ld = 0.30$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.08739136$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.08921201$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.04460601$

and confined core properties:

$b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $fcc \text{ (5A.2, TBDY)} = 21.84352$
 $cc \text{ (5A.5, TBDY)} = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.11923059$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.12171456$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.06085728$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su \text{ (4.9)} = 0.19929283$

$Mu = MRc \text{ (4.14)} = 8.0508E+007$

$u = su \text{ (4.1)} = 1.7861306E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of $Mu2$ -

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

$$\phi_u = 1.7938121E-005$$

$$\mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$\nu = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of $esu1_{nominal}$ and y_1 , sh_1 , f_{t1} , f_{y1} , it is considered
characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

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

characteristic value $fsy2 = fs2/1.2$, 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 $fs2 = fs = 311.2087$
 with $Es2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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
 $lo/lou, min = lb/ld = 0.30$
 $suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.08946191$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.08763615$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $fcc \text{ (5A.2, TBDY)} = 21.84352$
 $cc \text{ (5A.5, TBDY)} = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.12208678$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.11959521$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
 --->
 $su \text{ (4.9)} = 0.20048836$
 $Mu = MRc \text{ (4.14)} = 8.1848E+007$
 $u = su \text{ (4.1)} = 1.7938121E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 227880.93$

Calculation of Shear Strength at edge 1, $Vr1 = 227880.93$
 $Vr1 = Vn \text{ ((22.5.1.1), ACI 318-14)}$

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: $Vc = 78946.167$
 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $pw = As / (bw \cdot d) = 0.00628319$
 $As \text{ (tension reinf.)} = 603.1858$
 $bw = 300.00$
 $d = 320.00$
 $Vu \cdot d / Mu < 1 = 1.00$

$$M_u = 6709.869$$

$$V_u = 2740.264$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 148934.763$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$V_f ((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

Calculation of Shear Strength at edge 2, $V_{r2} = 227880.93$

$$V_{r2} = V_n ((22.5.1.1), \text{ACI 318-14})$$

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).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 78946.167$$

= 1 (normal-weight concrete)

$$f'_c = 20.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

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

$$A_s (\text{tension reinf.}) = 603.1858$$

$$b_w = 300.00$$

$$d = 320.00$$

$$V_u \cdot d / M_u < 1 = 1.00$$

$$M_u = 6709.869$$

$$V_u = 2740.264$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 148934.763$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$V_f ((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

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

$$\text{Knowledge Factor, } \phi = 0.85$$

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

Consequently:

$$\text{Existing material of Primary Member: Concrete Strength, } f_c = f_{cm} = 20.00$$

$$\text{Existing material of Primary Member: Steel Strength, } f_s = f_{sm} = 444.4444$$

$$\text{Concrete Elasticity, } E_c = 21019.039$$

$$\text{Steel Elasticity, } E_s = 200000.00$$

#####

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

$$\text{Existing material: Steel Strength, } f_s = 1.25 \cdot f_{sm} = 555.5556$$

#####

$$\text{Section Height, } H = 400.00$$

$$\text{Section Width, } W = 300.00$$

$$\text{Cover Thickness, } c = 25.00$$

$$\text{Mean Confinement Factor overall section} = 1.09218$$

$$\text{Element Length, } L = 1850.00$$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.9175078E-016$
EDGE -B-
Shear Force, $V_b = -4.9175078E-016$
BOTH EDGES
Axial Force, $F = -224.0408$
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, $V_e/V_r = 0.37910917$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.3467E+007$
 $Mu_{1+} = 5.3467E+007$, 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
 $Mu_{1-} = 5.3467E+007$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.3467E+007$
 $Mu_{2+} = 5.3467E+007$, 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
 $Mu_{2-} = 5.3467E+007$, 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
 $V_1 = 4.9175078E-016$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = -4.9175078E-016$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 2.5362472E-005$
 $M_u = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $\phi_o (5A.5, TBDY) = 0.002$
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_o) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.00777035$
we (5.4c) = 0.01139744

ase ((5.4d), TBDY) = 0.15672608
bo = 240.00
ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799

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 = 555.5556
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218

y1 = 0.0012967
sh1 = 0.0044814

ft1 = 373.4504

fy1 = 311.2087

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 = 311.2087

with Es1 = Es = 200000.00

y2 = 0.0012967

sh2 = 0.0044814

ft2 = 373.4504

fy2 = 311.2087

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 = 311.2087

with Es2 = Es = 200000.00

yv = 0.0012967

shv = 0.0044814

ftv = 373.4504

fyv = 311.2087

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 $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.07673736$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.07673736$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.07673736$

and confined core properties:

$b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.1021581$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.1021581$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.1021581$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:

$u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

$psh,x (5.4d) = 0.00349066$
 $Ash = Astir \cdot ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 300.00$

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

```

s = 150.00
fywe = 555.5556
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581

```


$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.1021581$$

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

--->

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

--->

$$s_u(4.9) = 0.21754625$$

$$M_u = M_{Rc}(4.14) = 5.3467E+007$$

$$u = s_u(4.1) = 2.5362472E-005$$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

Calculation of M_{u2+}

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

$$u = 2.5362472E-005$$

$$M_u = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} \cdot \max(\alpha, \alpha_c) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \alpha = 0.00777035$$

$$w_e(5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \alpha_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$I_o/I_{ou, min} = I_b/I_d = 0.30$$

$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 311.2087$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0012967$
 $sh2 = 0.0044814$
 $ft2 = 373.4504$
 $fy2 = 311.2087$
 $su2 = 0.00512$
 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 $fs2 = fs = 311.2087$
 with $Es2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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 $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b * d) * (fs1 / fc) = 0.07673736$
 $2 = Asl, com / (b * d) * (fs2 / fc) = 0.07673736$
 $v = Asl, mid / (b * d) * (fsv / fc) = 0.07673736$

and confined core properties:

$b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl, ten / (b * d) * (fs1 / fc) = 0.1021581$
 $2 = Asl, com / (b * d) * (fs2 / fc) = 0.1021581$
 $v = Asl, mid / (b * d) * (fsv / fc) = 0.1021581$

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

--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu2-

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

$$\mu = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e(5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

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.

$$\text{with } fs_1 = fs = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = fs = 311.2087$
 with $Es_v = Es = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.07673736$
 $2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.07673736$
 $v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.07673736$
 and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 152467.812$

Calculation of Shear Strength at edge 1, $V_{r1} = 152467.812$
 $V_{r1} = V_n ((22.5.1.1), ACI 318-14)$

 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: $V_c = 68692.008$
 $= 1$ (normal-weight concrete)
 $f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $pw = A_s/(b_w \cdot d) = 0.00628319$

As (tension reinf.) = 603.1858

bw = 400.00

d = 240.00

$V_u \cdot d / M_u < 1 = 0.00$

$M_u = 1.0885753E-012$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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

$2(1-s/d) = 0.75$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$V_{r2} = V_n ((22.5.1.1), \text{ACI } 318-14)$

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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

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

As (tension reinf.) = 603.1858

bw = 400.00

d = 240.00

$V_u \cdot d / M_u < 1 = 0.00$

$M_u = 1.7913670E-013$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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

$2(1-s/d) = 0.75$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

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, $\gamma = 0.85$

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:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M = 4.3080E+006$

Shear Force, $V_2 = -7.9210123E-015$

Shear Force, $V_3 = -2012.085$

Axial Force, $F = -506.3875$

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: $As_{mid} = 307.8761$

Mean Diameter of Tension Reinforcement, $Db_L = 16.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_R = \phi_u = 0.00761144$

$\phi_u = \phi_y + \phi_p = 0.00895463$

- Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00395463$ ((4.29), Biskinis Phd))

$M_y = 5.5905E+007$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 2141.073

From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 1.0089E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \min(\phi_{y,ten}, \phi_{y,com})$

$\phi_{y,ten} = 4.8148274E-006$

with ((10.1), ASCE 41-17) $f_y = \min(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 248.9669$

$d = 357.00$

$\phi_y = 0.27579298$

$A = 0.01427496$

$B = 0.0079338$

with $p_t = 0.00563199$

$p_c = 0.00574932$

$p_v = 0.00287466$

$N = 506.3875$

$b = 300.00$

$\phi_y = 0.11764706$

$\phi_{y,comp} = 1.7410083E-005$

with $f_c = 20.00$

$E_c = 21019.039$

$\phi_y = 0.27556281$

$A = 0.01424216$

$B = 0.00791481$

with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of p -

From table 10-7: $p = 0.005$

with:

- Condition iv occurred

Beam controlled by inadequate embedment into beam-column joint:
($l_b/l_d < 1$ 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 $V_p/V_o = 0.40051388$

- Transverse Reinforcement: NC

- Stirrup Spacing $> d/3$

- Low ductility demand, $\lambda / y < 2$ (table 10-6, ASCE 41-17)

$= 5.5448257E-005$

- Stirrup Spacing $\leq d/2$

$d = 357.00$

$s = 150.00$

- Strength provided by hoops $V_s < 3/4 \times \text{design Shear}$

$V_s = 148934.763$, already given in calculation of shear control ratio

design Shear = 2012.085

- ($\lambda - y$)/ λ = -0.16019328

$= A_{sl}/(b_w \times d) = 0.00563199$

Tension Reinf Area: $A_{sl} = 603.1858$

$\lambda = A_{sc}/(b_w \times d) = 0.00862398$

Compression Reinf Area: $A_{sc} = 923.6282$

From (B-1), ACI 318-11: $\lambda = 0.01867739$

$f_c = 20.00$

$f_y = 444.4444$

From 10.2.7.3, ACI 318-11: $\lambda = 0.85$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + y) = 0.57446809$

$y = 0.00222222$

- $V/(b_w \times d \times f_c^{0.5}) = 0.05059006$, 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. 3

beam B1, Floor 1

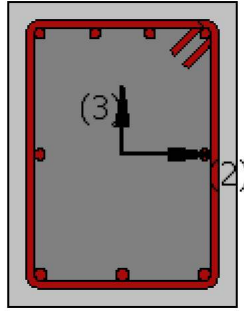
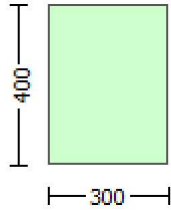
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (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, $\phi = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M_a = 4.3080E+006$

Shear Force, $V_a = -2012.085$

EDGE -B-

Bending Moment, $M_b = 4.4838E+006$

Shear Force, $V_b = 7492.614$

BOTH EDGES

Axial Force, $F = -506.3875$

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: $As_{mid} = 307.8761$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = *V_n = 167461.773$

$V_n ((22.5.1.1), ACI 318-14) = 197013.851$

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: $V_c = 62972.564$

= 1 (normal-weight concrete)

$f'_c = 16.00$, 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

$b_w = 300.00$

$d = 320.00$

$V_u * d / M_u < 1 = 0.1494578$

$M_u = 4.3080E+006$

$V_u = 2012.085$

From (11.5.4.8), ACI 318-14: $V_s = 134041.287$

$A_v = 157079.633$

$f_y = 400.00$

$s = 150.00$

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: $V_s + V_f \leq 255092.67$

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

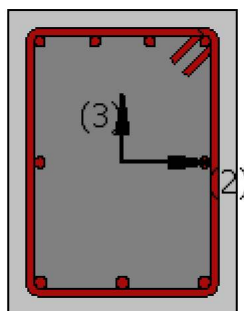
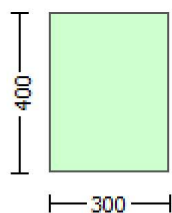
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$

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: $As_{l,com} = 615.7522$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.40051388$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$
with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.1931E+007$

$\mu_{u1+} = 8.0426E+007$, 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

$\mu_{u1-} = 8.1931E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.1848E+007$

$\mu_{u2+} = 8.0508E+007$, 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

$\mu_{u2-} = 8.1848E+007$, 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

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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 1.7898746E-005$$

$$M_u = 8.0426E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$\nu = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08,$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_s/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$s_{u2} = 0.00512$$

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
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 $fsy_v = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsy_v = fs_v/1.2$, 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 $fs_v = fs = 311.2087$
 with $Es_v = Es = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.08763615$
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.08946191$
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.11959521$
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.12208678$
 $v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.19872953$
 $Mu = MR_c (4.14) = 8.0426E+007$
 $u = su (4.1) = 1.7898746E-005$

 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:

$$u = 1.7900352E-005$$

$$Mu = 8.1931E+007$$

 with full section properties:

$$b = 300.00$$

$$d = 358.00$$

```

d' = 43.00
v = 0.0001043
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00
ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799
-----
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 = 555.5556
fce = 20.00
From ((5A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = fs = 311.2087$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.08921201$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.08739136$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.04460601$
and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.12171456$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.11923059$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.06085728$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.20103941$
 $Mu = MRc (4.14) = 8.1931E+007$
 $u = su (4.1) = 1.7900352E-005$

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:

$u = 1.7861306E-005$
 $Mu = 8.0508E+007$

with full section properties:

$b = 300.00$
 $d = 358.00$
 $d' = 43.00$
 $v = 0.0001043$
 $N = 224.0408$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi_2 = 346400.00$
 $psh_{min} = \text{Min}(psh_x, psh_y) = 0.00261799$

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 = 555.5556
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218

y1 = 0.0012967
sh1 = 0.0044814

ft1 = 373.4504

fy1 = 311.2087

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 = 311.2087

with Es1 = Es = 200000.00

y2 = 0.0012967

sh2 = 0.0044814

ft2 = 373.4504

fy2 = 311.2087

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 = 311.2087

with Es2 = Es = 200000.00

yv = 0.0012967

shv = 0.0044814

ftv = 373.4504

fyv = 311.2087

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 = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08739136

2 = Asl,com/(b*d)*(fs2/fc) = 0.08921201

v = Asl,mid/(b*d)*(fsv/fc) = 0.04460601

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$fcc(5A.2, TBDY) = 21.84352$$

$$cc(5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.11923059$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12171456$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.06085728$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$su(4.9) = 0.19929283$$

$$Mu = MRc(4.14) = 8.0508E+007$$

$$u = su(4.1) = 1.7861306E-005$$

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:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$fc = 20.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00777035$$

$$w_e(5.4c) = 0.01139744$$

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

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

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

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 300.00$$

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$


```

y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
    with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191
2 = Asl,com/(b*d)*(fs2/fc) = 0.08763615
v = Asl,mid/(b*d)*(fsv/fc) = 0.04473095
and confined core properties:
b = 240.00
d = 327.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12208678
2 = Asl,com/(b*d)*(fs2/fc) = 0.11959521
v = Asl,mid/(b*d)*(fsv/fc) = 0.06104339
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->

```

$\phi_u (4.9) = 0.20048836$
 $\phi_{uR} = \phi_{uRc} (4.14) = 8.1848E+007$
 $\phi_u = \phi_u (4.1) = 1.7938121E-005$

Calculation of ratio ϕ_b/ϕ_d

Inadequate Lap Length with $\phi_b/\phi_d = 0.30$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 227880.93$

Calculation of Shear Strength at edge 1, $V_{r1} = 227880.93$
 $V_{r1} = V_n ((22.5.1.1), \text{ACI 318-14})$

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: $V_c = 78946.167$
= 1 (normal-weight concrete)
 $f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $\rho_w = A_s/(b_w*d) = 0.00628319$
 A_s (tension reinf.) = 603.1858
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\phi_{uR} < 1 = 1.00$
 $\phi_{uR} = 6709.869$
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$
 $A_v = 157079.633$
 $f_y = 444.4444$
 $s = 150.00$

V_s has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 227880.93$
 $V_{r2} = V_n ((22.5.1.1), \text{ACI 318-14})$

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: $V_c = 78946.167$
= 1 (normal-weight concrete)
 $f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $\rho_w = A_s/(b_w*d) = 0.00628319$
 A_s (tension reinf.) = 603.1858
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\phi_{uR} < 1 = 1.00$
 $\phi_{uR} = 6709.869$
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$
 $A_v = 157079.633$
 $f_y = 444.4444$
 $s = 150.00$

V_s has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 4.9175078E-016$

EDGE -B-

Shear Force, $V_b = -4.9175078E-016$

BOTH EDGES

Axial Force, $F = -224.0408$

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: $A_{sl,ten} = 508.938$

-Compression: $A_{sl,com} = 508.938$

-Middle: $A_{sl,mid} = 508.938$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.37910917$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 5.3467E+007$

$\mu_{u1+} = 5.3467E+007$, 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

$\mu_{u1-} = 5.3467E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 5.3467E+007$

$\mu_{u2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 5.3467E+007$, 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 = 4.9175078E-016, is the shear force acting at edge 1 for the the static loading combination

V2 = -4.9175078E-016, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu1+

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

$$\phi_u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08,$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

```

ft2 = 373.4504
fy2 = 311.2087
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/lo,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 = 311.2087
    with Es2 = Es = 200000.00
    yv = 0.0012967
    shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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/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 Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-005

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu1-

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

u = 2.5362472E-005
Mu = 5.3467E+007

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_c: \phi_c = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_c = 0.00777035$$

$$\phi_w (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of $esu1_{nominal}$ and y_1 , sh_1 , f_{t1} , f_{y1} , it is considered
characteristic value $fsy_1 = f_s/1.2$, 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.

$$\text{with } fs_1 = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

For calculation of $esu2_{nominal}$ and y_2 , sh_2 , f_{t2} , f_{y2} , it is considered
characteristic value $fsy_2 = f_s/1.2$, 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.

$$\text{with } fs_2 = f_s = 311.2087$$

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

$$y_v = 0.0012967$$

```

shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
    c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-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 = 2.5362472E-005
Mu = 5.3467E+007

```

with full section properties:

```

b = 400.00
d = 258.00
d' = 42.00
v = 0.00010855
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00

```

ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799

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 = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 311.2087

with $E_s = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07673736$
and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.21754625$
 $Mu = MR_c (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:
 $u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00777035$
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

 $psh,x (5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y (5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$

```

fywe = 555.5556
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfinedsd full section - Steel rupture

```

satisfies Eq. (4.3)

--->

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

--->

$s_u(4.9) = 0.21754625$

$M_u = M_{Rc}(4.14) = 5.3467E+007$

$u = s_u(4.1) = 2.5362472E-005$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 152467.812$

Calculation of Shear Strength at edge 1, $V_{r1} = 152467.812$

$V_{r1} = V_n$ ((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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f_c' = 20.00$, 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

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 1.0885753E-012$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$V_{r2} = V_n$ ((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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f_c' = 20.00$, 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

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 1.7913670E-013$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$
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:
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups 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, $M = 2.8524885E-012$
Shear Force, $V_2 = -7.9210123E-015$
Shear Force, $V_3 = -2012.085$
Axial Force, $F = -506.3875$
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: $A_{sl,ten} = 508.938$
-Compression: $A_{sl,com} = 508.938$
-Middle: $A_{sl,mid} = 508.938$
Mean Diameter of Tension Reinforcement, $D_bL = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \phi \cdot u = 0.00602588$
 $u = y + p = 0.00708927$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00208927$ ((4.29), Biskinis Phd))
 $M_y = 3.8455E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 925.00
From table 10.5, ASCE 41_17: $E_{eff} = 0.3 \cdot E_c \cdot I_g = 5.6751E+012$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

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

$$y_{\text{ten}} = 6.7758046\text{E-}006$$

$$\text{with } ((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 248.9669$$

$$d = 258.00$$

$$y = 0.28791623$$

$$A = 0.01481442$$

$$B = 0.00862128$$

$$\text{with } p_t = 0.00493157$$

$$p_c = 0.00493157$$

$$p_v = 0.00493157$$

$$N = 506.3875$$

$$b = 400.00$$

$$r = 0.1627907$$

$$y_{\text{comp}} = 2.3074692\text{E-}005$$

$$\text{with } f_c = 20.00$$

$$E_c = 21019.039$$

$$y = 0.28769614$$

$$A = 0.01478038$$

$$B = 0.00860158$$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of ϕ_p -

From table 10-7: $\phi_p = 0.005$

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 $V_p/V_o = 0.37910917$

- Transverse Reinforcement: NC

- Stirrup Spacing $> d/3$

- Low ductility demand, $\phi_y < 2$ (table 10-6, ASCE 41-17)

$$= 2.0964072\text{E-}021$$

- Stirrup Spacing $> d/2$

$$d = 258.00$$

$$s = 150.00$$

- Strength provided by hoops $V_s < 3/4 \cdot \text{design Shear}$

$V_s = 111701.072$, already given in calculation of shear control ratio

design Shear = $7.9210123\text{E-}015$

- $(\phi - \phi')/ \phi_{\text{bal}} = -0.1662471$

$$= A_{\text{st}}/(b_w \cdot d) = 0.00584482$$

Tension Reinf Area: $A_{\text{st}} = 603.1858$

$$\phi' = A_{\text{sc}}/(b_w \cdot d) = 0.00894989$$

Compression Reinf Area: $A_{\text{sc}} = 923.6282$

From (B-1), ACI 318-11: $\phi_{\text{bal}} = 0.01867739$

$$f_c = 20.00$$

$$f_y = 444.4444$$

From 10.2.7.3, ACI 318-11: $\phi_1 = 0.85$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \phi_y) = 0.57446809$

$$\phi_y = 0.00222222$$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 2.0668513\text{E-}019$, 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

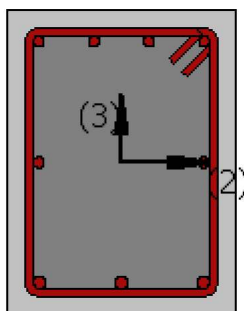
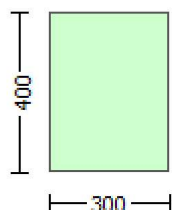
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M_a = 2.8524885E-012$

Shear Force, $V_a = -7.9210123E-015$

EDGE -B-

Bending Moment, $M_b = -1.7513979E-011$

Shear Force, $V_b = 7.9210123E-015$

BOTH EDGES

Axial Force, $F = -506.3875$

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: $As_{t,ten} = 508.938$

-Compression: $As_{c,com} = 508.938$

-Middle: $As_{mid} = 508.938$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 116312.49$
 $V_n ((22.5.1.1), ACI 318-14) = 136838.224$

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: $V_c = 61440.00$

= 1 (normal-weight concrete)

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

$\rho_w = As/(b_w*d) = 0.00641409$

As (tension reinf.) = 615.7522

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 1.7513979E-011$

$V_u = 7.9210123E-015$

From (11.5.4.8), ACI 318-14: $V_s = 75398.224$

$A_v = 157079.633$

$f_y = 400.00$

$s = 150.00$

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: $V_s + V_f \leq 255092.67$

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

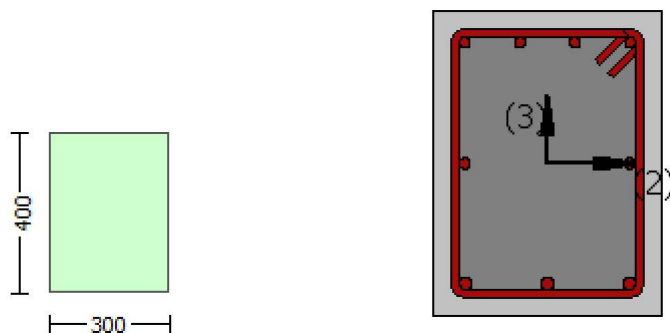
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\gamma = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$
 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: $As_{mid} = 307.8761$

 Calculation of Shear Capacity ratio, $V_e/V_r = 0.40051388$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 8.1931E+007$
 $\mu_{u1+} = 8.0426E+007$, 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
 $\mu_{u1-} = 8.1931E+007$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 8.1848E+007$
 $\mu_{u2+} = 8.0508E+007$, 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
 $\mu_{u2-} = 8.1848E+007$, 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
 $V_1 = 2740.264$, 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 μ_{u1+}

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

$\mu_u = 1.7898746E-005$
 $\mu_u = 8.0426E+007$

 with full section properties:

$b = 300.00$
 $d = 357.00$
 $d' = 42.00$
 $v = 0.00010459$
 $N = 224.0408$
 $f_c = 20.00$
 $\phi_c \text{ (5A.5, TBDY)} = 0.002$
 Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_{cu} = 0.00777035$
 $\phi_{we} \text{ (5.4c)} = 0.01139744$
 $\phi_{ase} \text{ ((5.4d), TBDY)} = 0.15672608$
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $\rho_{sh,min} = \text{Min}(\rho_{sh,x}, \rho_{sh,y}) = 0.00261799$

 $\rho_{sh,x} \text{ (5.4d)} = 0.00349066$
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 300.00$

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

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From } ((5.5), \text{TDY}), \text{TDY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y1 = 0.0012967$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4504$$

$$fy1 = 311.2087$$

$$su1 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 311.2087$$

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 311.2087$$

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

$$suv = 0.4 * esuv_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 311.2087$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.08763615$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.08946191$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.04473095$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, \text{TDY}) = 21.84352$$

$$cc (5A.5, \text{TDY}) = 0.00292176$$

$c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11959521$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12208678$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

$\mu_u(4.9) = 0.19872953$
 $M_u = M_{Rc}(4.14) = 8.0426E+007$
 $u = \mu_u(4.1) = 1.7898746E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$u = 1.7900352E-005$
 $M_u = 8.1931E+007$

with full section properties:

$b = 300.00$
 $d = 358.00$
 $d' = 43.00$
 $v = 0.0001043$
 $N = 224.0408$
 $f_c = 20.00$
 $\alpha(5A.5, TBDY) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.00777035$
 $\mu_{we}(5.4c) = 0.01139744$
 $\mu_{ase}((5.4d), TBDY) = 0.15672608$
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00261799$

$\mu_{psh,x}(5.4d) = 0.00349066$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 300.00$

$\mu_{psh,y}(5.4d) = 0.00261799$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 400.00$

$s = 150.00$
 $f_{ywe} = 555.5556$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $\mu_{cc} = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y_1 = 0.0012967$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4504$
 $fy_1 = 311.2087$
 $\mu_{su1} = 0.00512$
 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
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = fs = 311.2087$
with $Es_1 = Es = 200000.00$
 $y_2 = 0.0012967$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
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_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 $fs_2 = fs = 311.2087$
with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
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 $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = fs = 311.2087$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.08921201$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.08739136$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.04460601$
and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.12171456$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.11923059$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.06085728$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.20103941$
 $Mu = MRc (4.14) = 8.1931E+007$
 $u = su (4.1) = 1.7900352E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 1.7861306E-005$$

$$\mu_u = 8.0508E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$s_{u2} = 0.00512$$

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
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 $fsy_v = fsv/1.2$, 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 $fsv = fs = 311.2087$
 with $Es_v = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.08739136$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.08921201$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.04460601$
 and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.11923059$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.12171456$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.06085728$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.19929283$
 $Mu = MRc (4.14) = 8.0508E+007$
 $u = su (4.1) = 1.7861306E-005$

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:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$d = 357.00$
 $d' = 42.00$
 $v = 0.00010459$
 $N = 224.0408$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = Min(psh,x, psh,y) = 0.00261799$

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

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

$s = 150.00$
 $fywe = 555.5556$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00292176$
 $c = confinement\ factor = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$
 $ft1 = 373.4504$
 $fy1 = 311.2087$
 $su1 = 0.00512$
 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 $fs1 = fs = 311.2087$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0012967$
 $sh2 = 0.0044814$
 $ft2 = 373.4504$
 $fy2 = 311.2087$
 $su2 = 0.00512$
 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 $fs2 = fs = 311.2087$
 with $Es2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$

$suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08763615$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12208678$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.11959521$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.20048836$
 $Mu = MRc (4.14) = 8.1848E+007$
 $u = su (4.1) = 1.7938121E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $Vr = Min(Vr1,Vr2) = 227880.93$

Calculation of Shear Strength at edge 1, $Vr1 = 227880.93$
 $Vr1 = Vn ((22.5.1.1), ACI 318-14)$

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: $Vc = 78946.167$
 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, 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
 $bw = 300.00$
 $d = 320.00$
 $Vu*d/Mu < 1 = 1.00$
 $Mu = 6709.869$
 $Vu = 2740.264$
 From (11.5.4.8), ACI 318-14: $Vs = 148934.763$
 $Av = 157079.633$
 $fy = 444.4444$
 $s = 150.00$
 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: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 227880.93$

$V_{r2} = V_n$ ((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: $V_c = 78946.167$

= 1 (normal-weight concrete)

$f_c' = 20.00$, 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

$b_w = 300.00$

$d = 320.00$

$V_u \cdot d / M_u < 1 = 1.00$

$M_u = 6709.869$

$V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.9175078E-016$
EDGE -B-
Shear Force, $V_b = -4.9175078E-016$
BOTH EDGES
Axial Force, $F = -224.0408$
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: $A_{sl,ten} = 508.938$
-Compression: $A_{sl,com} = 508.938$
-Middle: $A_{sl,mid} = 508.938$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.37910917$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.3467E+007$
 $Mu_{1+} = 5.3467E+007$, 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
 $Mu_{1-} = 5.3467E+007$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.3467E+007$
 $Mu_{2+} = 5.3467E+007$, 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
 $Mu_{2-} = 5.3467E+007$, 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
 $V_1 = 4.9175078E-016$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = -4.9175078E-016$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 2.5362472E-005$
 $M_u = 5.3467E+007$

with full section properties:
 $b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $\phi_c (5A.5, TBDY) = 0.002$
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.00777035$
 $w_e (5.4c) = 0.01139744$
 $a_{se} ((5.4d), TBDY) = 0.15672608$
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

 $p_{sh,x} (5.4d) = 0.00349066$
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$
 $b_k = 300.00$

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

$s = 150.00$
 $f_{ywe} = 555.5556$
 $f_{ce} = 20.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00292176$
 $c = \text{confinement factor} = 1.09218$

$y_1 = 0.0012967$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4504$
 $fy_1 = 311.2087$
 $su_1 = 0.00512$

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 $fs_1 = fs = 311.2087$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0012967$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$

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_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 $fs_2 = fs = 311.2087$

with $Es_2 = Es = 200000.00$

$y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$

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 $fsyv = fsv/1.2$, 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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = fs = 311.2087$

with $Esv = Es = 200000.00$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.07673736$

$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.07673736$

$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.07673736$

and confined core properties:

$b = 340.00$

$d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:
 $u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

$psh,x (5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y (5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$
 $fy_{we} = 555.5556$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$

```

ft1 = 373.4504
fy1 = 311.2087
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*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 = 311.2087
    with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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,min = 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/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
    c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007

```

$$u = su(4.1) = 2.5362472E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2}

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

$$u = 2.5362472E-005$$

$$\mu_u = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \mu_{cu} = 0.00777035$$

$$\mu_{we}(5.4c) = 0.01139744$$

$$\mu_{ase}((5.4d), \text{TB DY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * \mu_{su1,nominal}((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \mu_{su1,nominal} = 0.08,$$

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

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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

```

sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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/lo,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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-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 = 2.5362472E-005

$$\mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00777035$$

$$\phi_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00292176$$

$$\phi_c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * \phi_{su1_nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su1_nominal} = 0.08,$$

For calculation of $\phi_{su1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

$$su_2 = 0.4 * \phi_{su2_nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su2_nominal} = 0.08,$$

For calculation of $\phi_{su2_nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s2} = f_s = 311.2087$$

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

$y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.07673736$
 $2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.07673736$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07673736$
 and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.1021581$
 $2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.1021581$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 152467.812$

Calculation of Shear Strength at edge 1, $V_{r1} = 152467.812$
 $V_{r1} = V_n ((22.5.1.1), ACI 318-14)$

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: $V_c = 68692.008$
 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $pw = As/(bw*d) = 0.00628319$
 As (tension reinf.) = 603.1858
 $bw = 400.00$
 $d = 240.00$
 $V_u*d/Mu < 1 = 0.00$
 $Mu = 1.0885753E-012$
 $V_u = 4.9175078E-016$
 From (11.5.4.8), ACI 318-14: $V_s = 83775.804$
 $Av = 157079.633$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$$V_{r2} = V_n((22.5.1.1), \text{ACI 318-14})$$

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).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 68692.008$$

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

$$f'_c = 20.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s/(b_w*d) = 0.00628319$$

$$A_s \text{ (tension reinf.)} = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u*d/M_u < 1 = 0.00$$

$$M_u = 1.7913670\text{E-}013$$

$$V_u = 4.9175078\text{E-}016$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 83775.804$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

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

$$\text{Knowledge Factor, } = 0.85$$

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:

$$\text{Existing material of Primary Member: Concrete Strength, } f_c = f_{cm} = 20.00$$

$$\text{Existing material of Primary Member: Steel Strength, } f_s = f_{sm} = 444.4444$$

$$\text{Concrete Elasticity, } E_c = 21019.039$$

$$\text{Steel Elasticity, } E_s = 200000.00$$

$$\text{Section Height, } H = 400.00$$

$$\text{Section Width, } W = 300.00$$

$$\text{Cover Thickness, } c = 25.00$$

$$\text{Element Length, } L = 1850.00$$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 4.4838\text{E}+006$
 Shear Force, $V2 = 7.9210123\text{E}-015$
 Shear Force, $V3 = 7492.614$
 Axial Force, $F = -506.3875$
 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, $Db_L = 14.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.00520813$
 $u = y + p = 0.00612721$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00112721$ ((4.29), Biskinis Phd))
 $M_y = 5.7012\text{E}+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 598.4317
 From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 1.0089\text{E}+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.8181749\text{E}-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 248.9669$
 $d = 358.00$
 $y = 0.27831765$
 $A = 0.01423508$
 $B = 0.00803225$
 with $p_t = 0.00573326$
 $p_c = 0.00561626$
 $p_v = 0.00286663$
 $N = 506.3875$
 $b = 300.00$
 $" = 0.12011173$
 $y_{comp} = 1.7203600\text{E}-005$
 with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.27809122$
 $A = 0.01420238$
 $B = 0.00801331$
 with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- 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 $V_p/V_o = 0.40051388$

- Transverse Reinforcement: NC

- Stirrup Spacing $> d/3$

- Low ductility demand, $\lambda / y < 2$ (table 10-6, ASCE 41-17)

$= 1.5475464E-005$

- Stirrup Spacing $\leq d/2$

$d = 358.00$

$s = 150.00$

- Strength provided by hoops $V_s < 3/4 \cdot \text{design Shear}$

$V_s = 148934.763$, already given in calculation of shear control ratio

design Shear = 7492.614

- ($\lambda - y$)/ $\lambda = -0.14721673$

$= A_{st}/(b_w \cdot d) = 0.00573326$

Tension Reinf Area: $A_{st} = 615.7522$

$\lambda = A_{sc}/(b_w \cdot d) = 0.00848289$

Compression Reinf Area: $A_{sc} = 911.0619$

From (B-1), ACI 318-11: $\lambda = 0.01867739$

$f_c = 20.00$

$f_y = 444.4444$

From 10.2.7.3, ACI 318-11: $\lambda = 0.85$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + y) = 0.57446809$

$y = 0.00222222$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 0.1878613$, 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

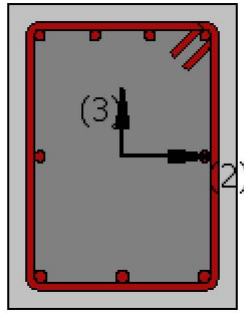
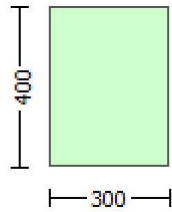
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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, $\phi = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M_a = 4.3080E+006$

Shear Force, $V_a = -2012.085$

EDGE -B-

Bending Moment, $M_b = 4.4838E+006$

Shear Force, $V_b = 7492.614$

BOTH EDGES

Axial Force, $F = -506.3875$

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: $As_{l,com} = 603.1858$

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

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 14.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = *V_n = 170916.926$

$V_n ((22.5.1.1), ACI 318-14) = 201078.737$

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: $V_c = 67037.45$

= 1 (normal-weight concrete)

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

$\rho_w = A_s / (b_w \cdot d) = 0.00641409$

A_s (tension reinf.) = 615.7522

$b_w = 300.00$

$d = 320.00$

$V_u \cdot d / M_u < 1 = 0.53473099$

$M_u = 4.4838E+006$

$V_u = 7492.614$

From (11.5.4.8), ACI 318-14: $V_s = 134041.287$

$A_v = 157079.633$

$f_y = 400.00$

$s = 150.00$

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

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

From (11-11), ACI 440: $V_s + V_f \leq 255092.67$

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

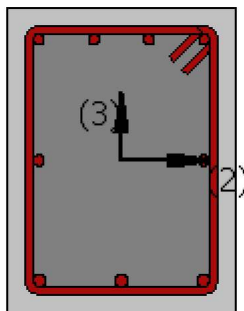
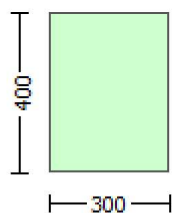
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$

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, $V_e/V_r = 0.40051388$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$

with $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.1931E+007$

$\mu_{u1+} = 8.0426E+007$, 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

$\mu_{u1-} = 8.1931E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.1848E+007$

$\mu_{u2+} = 8.0508E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 8.1848E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

and

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

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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 1.7898746E-005$$

$$M_u = 8.0426E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$\nu = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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 $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_s/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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 $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 $fsy_v = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsy_v = fs_v/1.2$, 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 $fs_v = fs = 311.2087$
 with $Es_v = Es = 200000.00$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.08763615$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.08946191$
 $v = A_{sl,mid}/(b * d) * (fs_v/f_c) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.11959521$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.12208678$
 $v = A_{sl,mid}/(b * d) * (fs_v/f_c) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.19872953$
 $Mu = MR_c (4.14) = 8.0426E+007$
 $u = su (4.1) = 1.7898746E-005$

 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:

$$u = 1.7900352E-005$$

$$Mu = 8.1931E+007$$

 with full section properties:

$$b = 300.00$$

$$d = 358.00$$

```

d' = 43.00
v = 0.0001043
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00
ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799
-----
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 = 555.5556
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 $fsyv = fsv/1.2$, 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.08921201$
 $2 = Asl_{com}/(b*d) * (fs2/fc) = 0.08739136$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.04460601$

and confined core properties:

$b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.12171456$
 $2 = Asl_{com}/(b*d) * (fs2/fc) = 0.11923059$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.06085728$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.20103941$
 $Mu = MRc (4.14) = 8.1931E+007$
 $u = su (4.1) = 1.7900352E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of $Mu2+$

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

$u = 1.7861306E-005$
 $Mu = 8.0508E+007$

with full section properties:

$b = 300.00$
 $d = 358.00$
 $d' = 43.00$
 $v = 0.0001043$
 $N = 224.0408$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

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 = 555.5556
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218

y1 = 0.0012967
sh1 = 0.0044814

ft1 = 373.4504

fy1 = 311.2087

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 = 311.2087

with Es1 = Es = 200000.00

y2 = 0.0012967

sh2 = 0.0044814

ft2 = 373.4504

fy2 = 311.2087

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 = 311.2087

with Es2 = Es = 200000.00

yv = 0.0012967

shv = 0.0044814

ftv = 373.4504

fyv = 311.2087

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 = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08739136

2 = Asl,com/(b*d)*(fs2/fc) = 0.08921201

v = Asl,mid/(b*d)*(fsv/fc) = 0.04460601

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$fcc(5A.2, TBDY) = 21.84352$$

$$cc(5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.11923059$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12171456$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.06085728$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su(4.9) = 0.19929283$$

$$Mu = MRc(4.14) = 8.0508E+007$$

$$u = su(4.1) = 1.7861306E-005$$

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:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$fc = 20.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00777035$$

$$w_e(5.4c) = 0.01139744$$

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

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

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

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 300.00$$

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

```

y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
    with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191
2 = Asl,com/(b*d)*(fs2/fc) = 0.08763615
v = Asl,mid/(b*d)*(fsv/fc) = 0.04473095
and confined core properties:
b = 240.00
d = 327.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12208678
2 = Asl,com/(b*d)*(fs2/fc) = 0.11959521
v = Asl,mid/(b*d)*(fsv/fc) = 0.06104339
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->

```

$$u = su(4.1) = 1.7938121E-005$$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 227880.93$

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

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

$$V_u = 2740.264$$

S = 150.00

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

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

$$V_{r2} = V_n ((22.5.1.1), \text{ACI } 318-14)$$

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

$$V_u = 2740.264$$

S = 150.00

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

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 4.9175078E-016$

EDGE -B-

Shear Force, $V_b = -4.9175078E-016$

BOTH EDGES

Axial Force, $F = -224.0408$

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: $A_{st,mid} = 508.938$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.37910917$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 5.3467E+007$

$\mu_{u1+} = 5.3467E+007$, 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

$\mu_{u1-} = 5.3467E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 5.3467E+007$

$\mu_{u2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 5.3467E+007$, 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 = 4.9175078E-016, is the shear force acting at edge 1 for the the static loading combination

V2 = -4.9175078E-016, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu1+

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

$$\phi_u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08,$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

```

ft2 = 373.4504
fy2 = 311.2087
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/lo,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 = 311.2087
    with Es2 = Es = 200000.00
    yv = 0.0012967
    shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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/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 Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-005

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu1-

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

u = 2.5362472E-005
Mu = 5.3467E+007

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_c: \phi_c = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \phi_c = 0.00777035$$

$$\phi_w (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * esu_{1,nominal} ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 311.2087$$

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

$$y_v = 0.0012967$$

```

shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
    c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-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 = 2.5362472E-005
Mu = 5.3467E+007

```

with full section properties:

```

b = 400.00
d = 258.00
d' = 42.00
v = 0.00010855
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00

```

ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799

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 = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 311.2087

with $E_s = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07673736$
and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.21754625$
 $Mu = MR_c (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:
 $u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00777035$
 $w_e (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

 $psh,x (5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y (5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$

```

fywe = 555.5556
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfinedsd full section - Steel rupture

```

satisfies Eq. (4.3)

--->

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

--->

$s_u(4.9) = 0.21754625$

$M_u = M_{Rc}(4.14) = 5.3467E+007$

$u = s_u(4.1) = 2.5362472E-005$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 152467.812$

Calculation of Shear Strength at edge 1, $V_{r1} = 152467.812$

$V_{r1} = V_n$ ((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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f_c' = 20.00$, 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

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 1.0885753E-012$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$V_{r2} = V_n$ ((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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f_c' = 20.00$, 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

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 1.7913670E-013$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$
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:
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups 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, $M = -1.7513979E-011$
Shear Force, $V_2 = 7.9210123E-015$
Shear Force, $V_3 = 7492.614$
Axial Force, $F = -506.3875$
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, $D_bL = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \phi \cdot u = 0.00602588$
 $u = y + p = 0.00708927$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00208927$ ((4.29), Biskinis Phd))
 $M_y = 3.8455E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 925.00
From table 10.5, ASCE 41_17: $E_{eff} = 0.3 \cdot E_c \cdot I_g = 5.6751E+012$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 6.7758046\text{E-}006$
with $((10.1), \text{ASCE } 41-17) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 248.9669$
 $d = 258.00$
 $y = 0.28791623$
 $A = 0.01481442$
 $B = 0.00862128$
with $p_t = 0.00493157$
 $p_c = 0.00493157$
 $p_v = 0.00493157$
 $N = 506.3875$
 $b = 400.00$
 $\mu = 0.1627907$
 $y_{\text{comp}} = 2.3074692\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.28769614$
 $A = 0.01478038$
 $B = 0.00860158$
with $E_s = 200000.00$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of ϕ_p -

From table 10-7: $\phi_p = 0.005$

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 $V_p/V_o = 0.37910917$
- Transverse Reinforcement: NC
- Stirrup Spacing $> d/3$
- Low ductility demand, $\phi_y < 2$ (table 10-6, ASCE 41-17)
 $\phi_y = -5.0000144\text{E-}022$
- Stirrup Spacing $> d/2$
 $d = 258.00$
 $s = 150.00$
- Strength provided by hoops $V_s < 3/4 \cdot \text{design Shear}$
 $V_s = 111701.072$, already given in calculation of shear control ratio
design Shear = $7.9210123\text{E-}015$
- $(\phi - \phi')/\phi_{\text{bal}} = -0.15320811$
 $\phi = A_{st}/(b_w \cdot d) = 0.00596659$
Tension Reinf Area: $A_{st} = 615.7522$
 $\phi' = A_{sc}/(b_w \cdot d) = 0.00882812$
Compression Reinf Area: $A_{sc} = 911.0619$
From (B-1), ACI 318-11: $\phi_{\text{bal}} = 0.01867739$
 $f_c = 20.00$
 $f_y = 444.4444$
From 10.2.7.3, ACI 318-11: $\phi_1 = 0.85$
From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \phi_y) = 0.57446809$
 $\phi_y = 0.00222222$
- $V/(b_w \cdot d \cdot f_c^{0.5}) = 2.0668513\text{E-}019$, 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

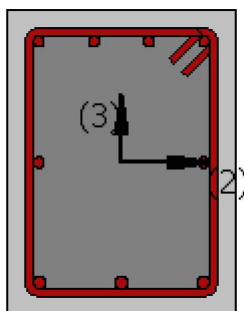
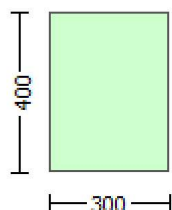
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M_a = 3.2956043E-012$

Shear Force, $V_a = -1.0034397E-014$

EDGE -B-

Bending Moment, $M_b = -2.1868695E-011$

Shear Force, $V_b = 1.0034397E-014$

BOTH EDGES

Axial Force, $F = -577.3164$

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, $Db_{L,ten} = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 116312.49$
 $V_n ((22.5.1.1), ACI 318-14) = 136838.224$

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: $V_c = 61440.00$

= 1 (normal-weight concrete)

$f_c' = 16.00$, 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

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 3.2956043E-012$

$V_u = 1.0034397E-014$

From (11.5.4.8), ACI 318-14: $V_s = 75398.224$

$A_v = 157079.633$

$f_y = 400.00$

$s = 150.00$

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: $V_s + V_f \leq 255092.67$

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

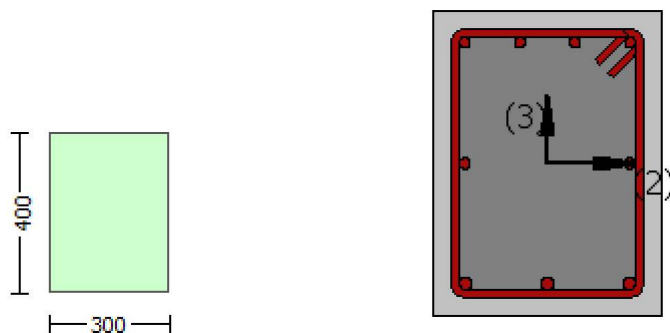
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$
 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: $As_{mid} = 307.8761$

 Calculation of Shear Capacity ratio, $V_e/V_r = 0.40051388$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 8.1931E+007$
 $\mu_{u1+} = 8.0426E+007$, 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
 $\mu_{u1-} = 8.1931E+007$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 8.1848E+007$
 $\mu_{u2+} = 8.0508E+007$, 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
 $\mu_{u2-} = 8.1848E+007$, 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
 $V_1 = 2740.264$, 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 μ_{u1+}

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

$\phi_u = 1.7898746E-005$
 $\mu_u = 8.0426E+007$

 with full section properties:

$b = 300.00$
 $d = 357.00$
 $d' = 42.00$
 $v = 0.00010459$
 $N = 224.0408$
 $f_c = 20.00$
 $\phi_c \text{ (5A.5, TBDY)} = 0.002$
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_u = 0.00777035$
 $w_e \text{ (5.4c)} = 0.01139744$
 $a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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

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

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From } ((5A.5), \text{TB DY}), \text{TB DY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y1 = 0.0012967$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4504$$

$$fy1 = 311.2087$$

$$su1 = 0.00512$$

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

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

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

From table 5A.1, TB DY: esu1_nominal = 0.08,

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

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

$$\text{with } fs1 = fs = 311.2087$$

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

From table 5A.1, TB DY: esu2_nominal = 0.08,

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

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

$$\text{with } fs2 = fs = 311.2087$$

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

$$suv = 0.4 * esuv_nominal ((5.5), \text{TB DY}) = 0.032$$

From table 5A.1, TB DY: esuv_nominal = 0.08,

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

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

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

$$\text{with } fsv = fs = 311.2087$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.08763615$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.08946191$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.04473095$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, \text{TB DY}) = 21.84352$$

$$cc (5A.5, \text{TB DY}) = 0.00292176$$

$c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11959521$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12208678$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

$\mu_u(4.9) = 0.19872953$
 $\mu_u = M_{Rc}(4.14) = 8.0426E+007$
 $u = \mu_u(4.1) = 1.7898746E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$u = 1.7900352E-005$
 $\mu_u = 8.1931E+007$

with full section properties:

$b = 300.00$
 $d = 358.00$
 $d' = 43.00$
 $v = 0.0001043$
 $N = 224.0408$
 $f_c = 20.00$
 $\alpha(5A.5, TBDY) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.00777035$
 $\mu_{we}(5.4c) = 0.01139744$
 $\mu_{ase}((5.4d), TBDY) = 0.15672608$
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00261799$

$\mu_{psh,x}(5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 300.00$

$\mu_{psh,y}(5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 400.00$

$s = 150.00$
 $f_{ywe} = 555.5556$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $\mu_{cc} = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y_1 = 0.0012967$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4504$
 $fy_1 = 311.2087$
 $\mu_{su1} = 0.00512$
 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
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = fs = 311.2087$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0012967$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
 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_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 $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/f_c) = 0.08921201$
 $2 = Asl_{com}/(b*d) * (fs_2/f_c) = 0.08739136$
 $v = Asl_{mid}/(b*d) * (fsv/f_c) = 0.04460601$
 and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs_1/f_c) = 0.12171456$
 $2 = Asl_{com}/(b*d) * (fs_2/f_c) = 0.11923059$
 $v = Asl_{mid}/(b*d) * (fsv/f_c) = 0.06085728$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.20103941$
 $Mu = MRc (4.14) = 8.1931E+007$
 $u = su (4.1) = 1.7900352E-005$

 Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 1.7861306E-005$$

$$\mu_u = 8.0508E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$s_{u2} = 0.00512$$

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
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
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 $fs_2 = fs = 311.2087$
with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
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 $fsy_v = fsv/1.2$, 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 $fsv = fs = 311.2087$
with $Es_v = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.08739136$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.08921201$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.04460601$
and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.11923059$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.12171456$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.06085728$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.19929283$
 $Mu = MRc (4.14) = 8.0508E+007$
 $u = su (4.1) = 1.7861306E-005$

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:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

```

d = 357.00
d' = 42.00
v = 0.00010459
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00
ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799
-----
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 = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087

```

$suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.08946191$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.08763615$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.12208678$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.11959521$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

--->
 $su (4.9) = 0.20048836$
 $Mu = MRc (4.14) = 8.1848E+007$
 $u = su (4.1) = 1.7938121E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $Vr = Min(Vr1, Vr2) = 227880.93$

Calculation of Shear Strength at edge 1, $Vr1 = 227880.93$
 $Vr1 = Vn ((22.5.1.1), ACI 318-14)$

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: $Vc = 78946.167$
 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, 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
 $bw = 300.00$
 $d = 320.00$
 $Vu * d / Mu < 1 = 1.00$
 $Mu = 6709.869$
 $Vu = 2740.264$
 From (11.5.4.8), ACI 318-14: $Vs = 148934.763$
 $Av = 157079.633$
 $fy = 444.4444$
 $s = 150.00$
 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: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 227880.93$

$V_{r2} = V_n$ ((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: $V_c = 78946.167$

= 1 (normal-weight concrete)

$f_c' = 20.00$, 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

$b_w = 300.00$

$d = 320.00$

$V_u*d/M_u < 1 = 1.00$

$M_u = 6709.869$

$V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25*f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.9175078E-016$
EDGE -B-
Shear Force, $V_b = -4.9175078E-016$
BOTH EDGES
Axial Force, $F = -224.0408$
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: $A_{sl,ten} = 508.938$
-Compression: $A_{sl,com} = 508.938$
-Middle: $A_{sl,mid} = 508.938$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.37910917$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.3467E+007$
 $Mu_{1+} = 5.3467E+007$, 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
 $Mu_{1-} = 5.3467E+007$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.3467E+007$
 $Mu_{2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{2-} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 4.9175078E-016$, is the shear force acting at edge 1 for the static loading combination
 $V_2 = -4.9175078E-016$, is the shear force acting at edge 2 for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 2.5362472E-005$
 $M_u = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $\phi_c (5A.5, TBDY) = 0.002$
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.00777035$
 $w_e (5.4c) = 0.01139744$
 $a_{se} ((5.4d), TBDY) = 0.15672608$
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$
 $p_{sh,x} (5.4d) = 0.00349066$
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$
 $b_k = 300.00$

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

 $s = 150.00$
 $f_{ywe} = 555.5556$
 $f_{ce} = 20.00$
From ((5.A.5), TBDY), TBDY: $c_c = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y_1 = 0.0012967$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4504$
 $fy_1 = 311.2087$
 $su_1 = 0.00512$
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 $fs_1 = fs = 311.2087$
with $E_{s1} = E_s = 200000.00$
 $y_2 = 0.0012967$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
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 $fs_2 = fs = 311.2087$
with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
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 $fsyv = fsv/1.2$, 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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = fs = 311.2087$
with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.07673736$
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.07673736$
 $v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.07673736$
and confined core properties:
 $b = 340.00$

$d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:
 $u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

$psh,x (5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y (5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$
 $fy_{we} = 555.5556$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$

```

ft1 = 373.4504
fy1 = 311.2087
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*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 = 311.2087
    with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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,min = 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/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
    c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007

```

$$u = su(4.1) = 2.5362472E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2}

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

$$u = 2.5362472E-005$$

$$\mu_u = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \mu_{cu} = 0.00777035$$

$$\mu_{we}(5.4c) = 0.01139744$$

$$\mu_{ase}((5.4d), \text{TB DY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * \mu_{su1,nominal}((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \mu_{su1,nominal} = 0.08,$$

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

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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

```

sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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/lo,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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-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 = 2.5362472E-005

$$\mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00777035$$

$$\phi_w (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00292176$$

$$\phi_c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * esu1_nominal ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y_1 , sh_1 , f_{t1} , f_{y1} , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

$$su_2 = 0.4 * esu2_nominal ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y_2 , sh_2 , f_{t2} , f_{y2} , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 311.2087$$

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

$y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.07673736$
 $2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.07673736$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07673736$
 and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.1021581$
 $2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.1021581$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 152467.812$

Calculation of Shear Strength at edge 1, $V_{r1} = 152467.812$
 $V_{r1} = V_n ((22.5.1.1), ACI 318-14)$

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: $V_c = 68692.008$
 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $pw = As/(bw*d) = 0.00628319$
 As (tension reinf.) = 603.1858
 $bw = 400.00$
 $d = 240.00$
 $V_u*d/Mu < 1 = 0.00$
 $Mu = 1.0885753E-012$
 $V_u = 4.9175078E-016$
 From (11.5.4.8), ACI 318-14: $V_s = 83775.804$
 $Av = 157079.633$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$$V_{r2} = V_n((22.5.1.1), \text{ACI 318-14})$$

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).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 68692.008$$

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

$$f'_c = 20.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s/(b_w*d) = 0.00628319$$

$$A_s \text{ (tension reinf.)} = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u*d/M_u < 1 = 0.00$$

$$M_u = 1.7913670\text{E-}013$$

$$V_u = 4.9175078\text{E-}016$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 83775.804$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

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

$$\text{Knowledge Factor, } = 0.85$$

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:

$$\text{Existing material of Primary Member: Concrete Strength, } f_c = f_{cm} = 20.00$$

$$\text{Existing material of Primary Member: Steel Strength, } f_s = f_{sm} = 444.4444$$

$$\text{Concrete Elasticity, } E_c = 21019.039$$

$$\text{Steel Elasticity, } E_s = 200000.00$$

$$\text{Section Height, } H = 400.00$$

$$\text{Section Width, } W = 300.00$$

$$\text{Cover Thickness, } c = 25.00$$

$$\text{Element Length, } L = 1850.00$$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 5.3886E+006$
 Shear Force, $V2 = -1.0034397E-014$
 Shear Force, $V3 = -3205.931$
 Axial Force, $F = -577.3164$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $Asl_t = 603.1858$
 -Compression: $Asl_c = 923.6282$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl_{ten} = 603.1858$
 -Compression: $Asl_{com} = 615.7522$
 -Middle: $Asl_{mid} = 307.8761$
 Mean Diameter of Tension Reinforcement, $DbL = 16.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.02813934$
 $u = y + p = 0.0331051$

- Calculation of y -

$y = (My * Ls / 3) / E_{eff} = 0.0031051$ ((4.29), Biskinis Phd))
 $My = 5.5916E+007$
 $Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1680.81
 From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 1.0089E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.8151234E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 248.9669$
 $d = 357.00$
 $y = 0.2758375$
 $A = 0.01427762$
 $B = 0.00793646$
 with $pt = 0.00563199$
 $pc = 0.00574932$
 $pv = 0.00287466$
 $N = 577.3164$
 $b = 300.00$
 $" = 0.11764706$
 $y_{comp} = 1.7409303E-005$
 with $fc = 20.00$
 $E_c = 21019.039$
 $y = 0.27557514$
 $A = 0.01424023$
 $B = 0.00791481$
 with $Es = 200000.00$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

- Calculation of p -

From table 10-7: $p = 0.03$
 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 $V_p/V_o = 0.40051388$

- Transverse Reinforcement: NC

- Stirrup Spacing $> d/3$

- Low ductility demand, $\lambda / y < 2$ (table 10-6, ASCE 41-17)

$= 6.3730382E-005$

- Stirrup Spacing $\leq d/2$

$d = 357.00$

$s = 150.00$

- Strength provided by hoops $V_s < 3/4 \cdot \text{design Shear}$

$V_s = 148934.763$, already given in calculation of shear control ratio

design Shear = 3205.931

- ($\lambda - y$)/ $\text{bal} = -0.16019328$

$= A_{sl}/(b_w \cdot d) = 0.00563199$

Tension Reinf Area: $A_{sl} = 603.1858$

$\lambda = A_{sl}/(b_w \cdot d) = 0.00862398$

Compression Reinf Area: $A_{slc} = 923.6282$

From (B-1), ACI 318-11: $\text{bal} = 0.01867739$

$f_c = 20.00$

$f_y = 444.4444$

From 10.2.7.3, ACI 318-11: $\lambda = 0.85$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + y) = 0.57446809$

$y = 0.00222222$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 0.08060704$, 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

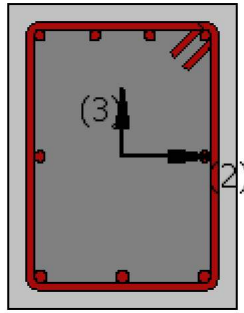
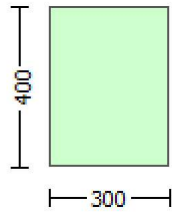
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcars

Constant Properties

Knowledge Factor, $\phi = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M_a = 5.3886E+006$

Shear Force, $V_a = -3205.931$

EDGE -B-

Bending Moment, $M_b = 5.6119E+006$

Shear Force, $V_b = 8686.46$

BOTH EDGES

Axial Force, $F = -577.3164$

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: $As_{l,com} = 615.7522$

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

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = *V_n = 167818.491$

$V_n ((22.5.1.1), ACI 318-14) = 197433.519$

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: $V_c = 63392.232$

= 1 (normal-weight concrete)

$f'_c = 16.00$, 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

$b_w = 300.00$

$d = 320.00$

$V_u * d / M_u < 1 = 0.19038443$

$M_u = 5.3886E+006$

$V_u = 3205.931$

From (11.5.4.8), ACI 318-14: $V_s = 134041.287$

$A_v = 157079.633$

$f_y = 400.00$

$s = 150.00$

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: $V_s + V_f \leq 255092.67$

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

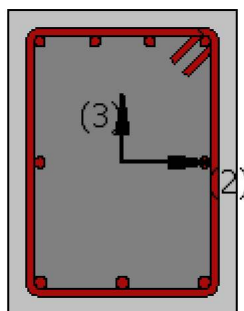
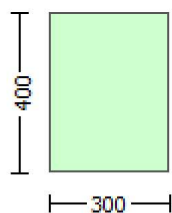
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$

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: $As_{l,com} = 615.7522$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.40051388$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$
with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.1931E+007$

$\mu_{u1+} = 8.0426E+007$, 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

$\mu_{u1-} = 8.1931E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.1848E+007$

$\mu_{u2+} = 8.0508E+007$, 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

$\mu_{u2-} = 8.1848E+007$, 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

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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7898746E-005$$

$$Mu = 8.0426E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_o) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00777035$$

$$\phi_{ue} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08,$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_s/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$s_{u2} = 0.00512$$

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
 $l_o/l_{o,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 $fsy_v = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsy_v = fs_v/1.2$, 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 $fs_v = fs = 311.2087$
 with $Es_v = Es = 200000.00$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.08763615$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.08946191$
 $v = A_{sl,mid}/(b * d) * (fs_v/f_c) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.11959521$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.12208678$
 $v = A_{sl,mid}/(b * d) * (fs_v/f_c) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.19872953$
 $Mu = MR_c (4.14) = 8.0426E+007$
 $u = su (4.1) = 1.7898746E-005$

 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:

$$u = 1.7900352E-005$$

$$Mu = 8.1931E+007$$

 with full section properties:

$$b = 300.00$$

$$d = 358.00$$

```

d' = 43.00
v = 0.0001043
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00
ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799
-----
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 = 555.5556
fce = 20.00
From ((5A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 $fsyv = fsv/1.2$, 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = fs = 311.2087$
with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.08921201$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08739136$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04460601$
and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12171456$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.11923059$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.06085728$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.20103941$
 $Mu = MRc (4.14) = 8.1931E+007$
 $u = su (4.1) = 1.7900352E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of $Mu2+$

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

$u = 1.7861306E-005$
 $Mu = 8.0508E+007$

with full section properties:

$b = 300.00$
 $d = 358.00$
 $d' = 43.00$
 $v = 0.0001043$
 $N = 224.0408$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu* = shear_factor * Max(cu, cc) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = Min(psh,x, psh,y) = 0.00261799$

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 = 555.5556
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218

y1 = 0.0012967
sh1 = 0.0044814

ft1 = 373.4504

fy1 = 311.2087

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*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 = 311.2087

with Es1 = Es = 200000.00

y2 = 0.0012967

sh2 = 0.0044814

ft2 = 373.4504

fy2 = 311.2087

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 = 311.2087

with Es2 = Es = 200000.00

yv = 0.0012967

shv = 0.0044814

ftv = 373.4504

fyv = 311.2087

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,min = 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/lb)^2/3), from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08739136

2 = Asl,com/(b*d)*(fs2/fc) = 0.08921201

v = Asl,mid/(b*d)*(fsv/fc) = 0.04460601

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$fcc(5A.2, TBDY) = 21.84352$$

$$cc(5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.11923059$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12171456$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.06085728$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su(4.9) = 0.19929283$$

$$Mu = MRc(4.14) = 8.0508E+007$$

$$u = su(4.1) = 1.7861306E-005$$

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:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$fc = 20.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00777035$$

$$w_e(5.4c) = 0.01139744$$

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

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

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

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 300.00$$

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

```

y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
    with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191
2 = Asl,com/(b*d)*(fs2/fc) = 0.08763615
v = Asl,mid/(b*d)*(fsv/fc) = 0.04473095
and confined core properties:
b = 240.00
d = 327.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12208678
2 = Asl,com/(b*d)*(fs2/fc) = 0.11959521
v = Asl,mid/(b*d)*(fsv/fc) = 0.06104339
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->

```

$\phi_u(4.9) = 0.20048836$
 $\phi_{uRc}(4.14) = 8.1848E+007$
 $u = \phi_u(4.1) = 1.7938121E-005$

Calculation of ratio ϕ_b/ϕ_d

Inadequate Lap Length with $\phi_b/\phi_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 227880.93$

Calculation of Shear Strength at edge 1, $V_{r1} = 227880.93$
 $V_{r1} = V_n((22.5.1.1), \text{ACI } 318-14)$

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: $V_c = 78946.167$
= 1 (normal-weight concrete)
 $f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $\rho_w = A_s/(b_w*d) = 0.00628319$
 A_s (tension reinf.) = 603.1858
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\phi_{uRc} < 1 = 1.00$
 $\phi_{uRc} = 6709.869$
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$
 $A_v = 157079.633$
 $f_y = 444.4444$
 $s = 150.00$

V_s has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f((11-3)-(11.4), \text{ACI } 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 227880.93$
 $V_{r2} = V_n((22.5.1.1), \text{ACI } 318-14)$

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: $V_c = 78946.167$
= 1 (normal-weight concrete)
 $f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $\rho_w = A_s/(b_w*d) = 0.00628319$
 A_s (tension reinf.) = 603.1858
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\phi_{uRc} < 1 = 1.00$
 $\phi_{uRc} = 6709.869$
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$
 $A_v = 157079.633$
 $f_y = 444.4444$
 $s = 150.00$

V_s has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f((11-3)-(11.4), \text{ACI } 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 4.9175078E-016$

EDGE -B-

Shear Force, $V_b = -4.9175078E-016$

BOTH EDGES

Axial Force, $F = -224.0408$

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: $A_{sl,ten} = 508.938$

-Compression: $A_{sl,com} = 508.938$

-Middle: $A_{sl,mid} = 508.938$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.37910917$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 5.3467E+007$

$\mu_{u1+} = 5.3467E+007$, 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

$\mu_{u1-} = 5.3467E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 5.3467E+007$

$\mu_{u2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 5.3467E+007$, 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 = 4.9175078E-016, is the shear force acting at edge 1 for the the static loading combination

V2 = -4.9175078E-016, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu1+

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

$$\phi_u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $s_{u1_nominal} = 0.08$,

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

```

ft2 = 373.4504
fy2 = 311.2087
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/lo,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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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/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 Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-005

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu1-

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

u = 2.5362472E-005
Mu = 5.3467E+007

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_c: \phi_c = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \phi_c = 0.00777035$$

$$\phi_w (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * esu1_{nominal} ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

$$su_2 = 0.4 * esu2_{nominal} ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 311.2087$$

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

$$y_v = 0.0012967$$


```

shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
    c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-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 = 2.5362472E-005
Mu = 5.3467E+007

```

with full section properties:

```

b = 400.00
d = 258.00
d' = 42.00
v = 0.00010855
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00

```

$h_o = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

$psh,x (5.4d) = 0.00349066$
 $Ash = Astir*ns = 78.53982$
 $No \text{ stirups}, ns = 2.00$
 $bk = 300.00$

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

$s = 150.00$
 $fywe = 555.5556$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$
 $ft1 = 373.4504$
 $fy1 = 311.2087$
 $su1 = 0.00512$
 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 $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 311.2087$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0012967$
 $sh2 = 0.0044814$
 $ft2 = 373.4504$
 $fy2 = 311.2087$
 $su2 = 0.00512$
 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 $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 311.2087$
 with $Es2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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 $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$

with $E_s = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07673736$
 and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:
 $u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $w_e (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

$psh,x (5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y (5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$

```

fywe = 555.5556
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfinedsd full section - Steel rupture

```

satisfies Eq. (4.3)

--->

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

--->

$s_u(4.9) = 0.21754625$

$M_u = M_{Rc}(4.14) = 5.3467E+007$

$u = s_u(4.1) = 2.5362472E-005$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 152467.812$

Calculation of Shear Strength at edge 1, $V_{r1} = 152467.812$

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

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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$p_w = A_s/(b_w*d) = 0.00628319$

A_s (tension reinf.) = 603.1858

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 1.0885753E-012$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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

$2(1-s/d) = 0.75$

$V_f((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$V_{r2} = V_n((22.5.1.1), \text{ACI } 318-14)$

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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$p_w = A_s/(b_w*d) = 0.00628319$

A_s (tension reinf.) = 603.1858

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 1.7913670E-013$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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

$2(1-s/d) = 0.75$

$V_f((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$
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:
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups 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, $M = 3.2956043E-012$
Shear Force, $V_2 = -1.0034397E-014$
Shear Force, $V_3 = -3205.931$
Axial Force, $F = -577.3164$
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: $A_{st,mid} = 508.938$
Mean Diameter of Tension Reinforcement, $D_bL = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \phi \cdot u = 0.02727624$
 $u = y + p = 0.03208969$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00208969$ ((4.29), Biskinis Phd))
 $M_y = 3.8463E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 925.00
From table 10.5, ASCE 41_17: $E_{eff} = 0.3 \cdot E_c \cdot I_g = 5.6751E+012$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 6.7762196\text{E-}006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25*f_y*(l_b/d)^{2/3}) = 248.9669$
 $d = 258.00$
 $y = 0.28795984$
 $A = 0.01481718$
 $B = 0.00862404$
with $p_t = 0.00493157$
 $p_c = 0.00493157$
 $p_v = 0.00493157$
 $N = 577.3164$
 $b = 400.00$
 $\mu = 0.1627907$
 $y_{\text{comp}} = 2.3073663\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.28770896$
 $A = 0.01477838$
 $B = 0.00860158$
with $E_s = 200000.00$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of ϕ_p -

From table 10-7: $\phi_p = 0.03$

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 $V_p/V_o = 0.37910917$
- Transverse Reinforcement: NC
- Stirrup Spacing $> d/3$
- Low ductility demand, $\phi_y < 2$ (table 10-6, ASCE 41-17)
 $\phi_y = 2.6052417\text{E-}021$
- Stirrup Spacing $> d/2$
 $d = 258.00$
 $s = 150.00$
- Strength provided by hoops $V_s < 3/4$ *design Shear
 $V_s = 111701.072$, already given in calculation of shear control ratio
design Shear = $1.0034397\text{E-}014$
- ($\phi_c - \phi_y$)/ $\phi_{bal} = -0.1662471$
 $\phi_c = A_{st}/(b_w*d) = 0.00584482$
Tension Reinf Area: $A_{st} = 603.1858$
 $\phi_y = A_{sc}/(b_w*d) = 0.00894989$
Compression Reinf Area: $A_{sc} = 923.6282$
From (B-1), ACI 318-11: $\phi_{bal} = 0.01867739$
 $f_c = 20.00$
 $f_y = 444.4444$
From 10.2.7.3, ACI 318-11: $\phi_1 = 0.85$
From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \phi_y) = 0.57446809$
 $\phi_y = 0.00222222$
- $V/(b_w*d*f_c^{0.5}) = 2.6183026\text{E-}019$, 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

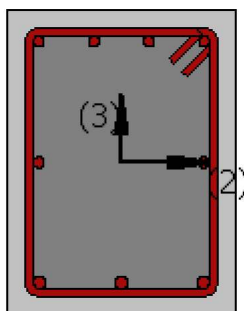
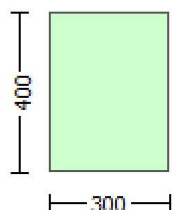
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M_a = 3.2956043E-012$

Shear Force, $V_a = -1.0034397E-014$

EDGE -B-

Bending Moment, $M_b = -2.1868695E-011$

Shear Force, $V_b = 1.0034397E-014$

BOTH EDGES

Axial Force, $F = -577.3164$

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: $As_{t,ten} = 508.938$

-Compression: $As_{c,com} = 508.938$

-Middle: $As_{mid} = 508.938$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 116312.49$
 $V_n ((22.5.1.1), ACI 318-14) = 136838.224$

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: $V_c = 61440.00$

= 1 (normal-weight concrete)

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

$\rho_w = As/(b_w*d) = 0.00641409$

As (tension reinf.) = 615.7522

$b_w = 400.00$

$d = 240.00$

$V_u*d/M_u < 1 = 0.00$

$M_u = 2.1868695E-011$

$V_u = 1.0034397E-014$

From (11.5.4.8), ACI 318-14: $V_s = 75398.224$

$A_v = 157079.633$

$f_y = 400.00$

$s = 150.00$

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: $V_s + V_f \leq 255092.67$

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

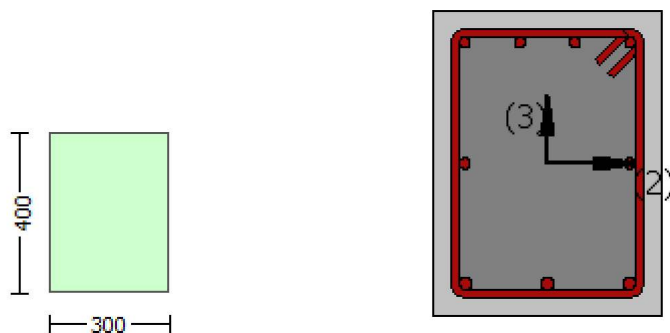
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$
 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: $As_{mid} = 307.8761$

 Calculation of Shear Capacity ratio, $V_e/V_r = 0.40051388$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 8.1931E+007$
 $\mu_{u1+} = 8.0426E+007$, 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
 $\mu_{u1-} = 8.1931E+007$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 8.1848E+007$
 $\mu_{u2+} = 8.0508E+007$, 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
 $\mu_{u2-} = 8.1848E+007$, 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
 $V_1 = 2740.264$, 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 μ_{u1+}

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

$\phi_u = 1.7898746E-005$
 $\mu_u = 8.0426E+007$

 with full section properties:

$b = 300.00$
 $d = 357.00$
 $d' = 42.00$
 $v = 0.00010459$
 $N = 224.0408$
 $f_c = 20.00$
 ϕ_c (5A.5, TBDY) = 0.002
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_u = 0.00777035$
 w_e (5.4c) = 0.01139744
 a_{se} ((5.4d), TBDY) = 0.15672608
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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

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

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From } ((5.5), \text{TDY}), \text{TDY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y1 = 0.0012967$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4504$$

$$fy1 = 311.2087$$

$$su1 = 0.00512$$

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

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

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

From table 5A.1, TDY: 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, TDY.

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

$$\text{with } fs1 = fs = 311.2087$$

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

From table 5A.1, TDY: 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, TDY.

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

$$\text{with } fs2 = fs = 311.2087$$

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

$$suv = 0.4 * esuv_nominal ((5.5), \text{TDY}) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 311.2087$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.08763615$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.08946191$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.04473095$$

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

$$fcc (5A.2, \text{TDY}) = 21.84352$$

$$cc (5A.5, \text{TDY}) = 0.00292176$$

$c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11959521$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12208678$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su(4.9) = 0.19872953$
 $Mu = MRc(4.14) = 8.0426E+007$
 $u = su(4.1) = 1.7898746E-005$

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:

$u = 1.7900352E-005$
 $Mu = 8.1931E+007$

with full section properties:

$b = 300.00$
 $d = 358.00$
 $d' = 43.00$
 $v = 0.0001043$
 $N = 224.0408$
 $f_c = 20.00$
 $co(5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $w_e(5.4c) = 0.01139744$
 $ase((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

$psh,x(5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y(5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$
 $fy_{we} = 555.5556$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$
 $ft1 = 373.4504$
 $fy1 = 311.2087$
 $su1 = 0.00512$
 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
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = fs = 311.2087$
with $Es_1 = Es = 200000.00$
 $y_2 = 0.0012967$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
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_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 $fs_2 = fs = 311.2087$
with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
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 $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = fs = 311.2087$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.08921201$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.08739136$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.04460601$
and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.12171456$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.11923059$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.06085728$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.20103941$
 $Mu = MRc (4.14) = 8.1931E+007$
 $u = su (4.1) = 1.7900352E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 1.7861306E-005$$

$$\mu_u = 8.0508E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$\nu = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$s_{u2} = 0.00512$$

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
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 $fsy_v = fsv/1.2$, 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 $fsv = fs = 311.2087$
 with $Es_v = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.08739136$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.08921201$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.04460601$
 and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b * d) * (fs_1/f_c) = 0.11923059$
 $2 = Asl_{com}/(b * d) * (fs_2/f_c) = 0.12171456$
 $v = Asl_{mid}/(b * d) * (fsv/f_c) = 0.06085728$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.19929283$
 $Mu = MRc (4.14) = 8.0508E+007$
 $u = su (4.1) = 1.7861306E-005$

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:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$d = 357.00$
 $d' = 42.00$
 $v = 0.00010459$
 $N = 224.0408$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = Min(psh,x, psh,y) = 0.00261799$

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

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

$s = 150.00$
 $fywe = 555.5556$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00292176$
 $c = confinement\ factor = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$
 $ft1 = 373.4504$
 $fy1 = 311.2087$
 $su1 = 0.00512$
 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 $fs1 = fs = 311.2087$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0012967$
 $sh2 = 0.0044814$
 $ft2 = 373.4504$
 $fy2 = 311.2087$
 $su2 = 0.00512$
 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 $fs2 = fs = 311.2087$
 with $Es2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$

$suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08763615$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12208678$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.11959521$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.20048836$
 $Mu = MRc (4.14) = 8.1848E+007$
 $u = su (4.1) = 1.7938121E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $Vr = Min(Vr1, Vr2) = 227880.93$

Calculation of Shear Strength at edge 1, $Vr1 = 227880.93$
 $Vr1 = Vn ((22.5.1.1), ACI 318-14)$

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: $Vc = 78946.167$
 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, 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
 $bw = 300.00$
 $d = 320.00$
 $Vu*d/Mu < 1 = 1.00$
 $Mu = 6709.869$
 $Vu = 2740.264$
 From (11.5.4.8), ACI 318-14: $Vs = 148934.763$
 $Av = 157079.633$
 $fy = 444.4444$
 $s = 150.00$
 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: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 227880.93$

$V_{r2} = V_n$ ((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: $V_c = 78946.167$

= 1 (normal-weight concrete)

$f'_c = 20.00$, 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

$b_w = 300.00$

$d = 320.00$

$V_u \cdot d / M_u < 1 = 1.00$

$M_u = 6709.869$

$V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.9175078E-016$
EDGE -B-
Shear Force, $V_b = -4.9175078E-016$
BOTH EDGES
Axial Force, $F = -224.0408$
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: $A_{sl,ten} = 508.938$
-Compression: $A_{sl,com} = 508.938$
-Middle: $A_{sl,mid} = 508.938$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.37910917$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.3467E+007$
 $Mu_{1+} = 5.3467E+007$, 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
 $Mu_{1-} = 5.3467E+007$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.3467E+007$
 $Mu_{2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{2-} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 4.9175078E-016$, is the shear force acting at edge 1 for the static loading combination
 $V_2 = -4.9175078E-016$, is the shear force acting at edge 2 for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 2.5362472E-005$
 $M_u = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 ϕ_0 (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.00777035$
 w_e (5.4c) = 0.01139744
 a_{se} ((5.4d), TBDY) = 0.15672608
 $b_o = 240.00$
 $h_o = 340.00$
 $b_{i2} = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$
 $p_{sh,x}$ (5.4d) = 0.00349066
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$
 $b_k = 300.00$

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

 $s = 150.00$
 $f_{ywe} = 555.5556$
 $f_{ce} = 20.00$
From ((5.A.5), TBDY), TBDY: $c_c = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y_1 = 0.0012967$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4504$
 $fy_1 = 311.2087$
 $su_1 = 0.00512$
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 $fs_1 = fs = 311.2087$
with $E_{s1} = E_s = 200000.00$
 $y_2 = 0.0012967$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
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_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 $fs_2 = fs = 311.2087$
with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
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 $fsyv = fsv/1.2$, 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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = fs = 311.2087$
with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.07673736$
 $2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.07673736$
 $v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.07673736$
and confined core properties:
 $b = 340.00$

$d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:
 $u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

$psh,x (5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y (5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$
 $fy_{we} = 555.5556$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $y1 = 0.0012967$
 $sh1 = 0.0044814$

```

ft1 = 373.4504
fy1 = 311.2087
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*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 = 311.2087
    with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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,min = 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/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
    c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007

```

$$u = su(4.1) = 2.5362472E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2}

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

$$u = 2.5362472E-005$$

$$\mu_u = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.00777035$$

$$\mu_{we}(5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

$$su_1 = 0.4 * \mu_{su1_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \mu_{su1_nominal} = 0.08,$$

For calculation of $\mu_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$


```

sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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/lo,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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-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 = 2.5362472E-005

$$\mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00777035$$

$$\phi_w (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5A5), TB DY), TB DY: } \phi_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of $esu_1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

$$su_2 = 0.4 * esu_2_{nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_2_{nominal} = 0.08,$$

For calculation of $esu_2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 311.2087$$

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

$y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736$
 and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21754625$
 $Mu = MRc (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = Min(Vr1, Vr2) = 152467.812$

Calculation of Shear Strength at edge 1, $Vr1 = 152467.812$
 $Vr1 = Vn ((22.5.1.1), ACI 318-14)$

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: $Vc = 68692.008$
 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, 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
 $bw = 400.00$
 $d = 240.00$
 $Vu*d/Mu < 1 = 0.00$
 $Mu = 1.0885753E-012$
 $Vu = 4.9175078E-016$
 From (11.5.4.8), ACI 318-14: $Vs = 83775.804$
 $Av = 157079.633$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$$V_{r2} = V_n((22.5.1.1), \text{ACI 318-14})$$

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).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 68692.008$$

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

$$f'_c = 20.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s/(b_w*d) = 0.00628319$$

$$A_s \text{ (tension reinf.)} = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u*d/M_u < 1 = 0.00$$

$$M_u = 1.7913670\text{E-}013$$

$$V_u = 4.9175078\text{E-}016$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 83775.804$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

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

$$\text{Knowledge Factor, } = 0.85$$

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:

$$\text{Existing material of Primary Member: Concrete Strength, } f_c = f_{cm} = 20.00$$

$$\text{Existing material of Primary Member: Steel Strength, } f_s = f_{sm} = 444.4444$$

$$\text{Concrete Elasticity, } E_c = 21019.039$$

$$\text{Steel Elasticity, } E_s = 200000.00$$

$$\text{Section Height, } H = 400.00$$

$$\text{Section Width, } W = 300.00$$

$$\text{Cover Thickness, } c = 25.00$$

$$\text{Element Length, } L = 1850.00$$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 5.6119\text{E}+006$
 Shear Force, $V2 = 1.0034397\text{E}-014$
 Shear Force, $V3 = 8686.46$
 Axial Force, $F = -577.3164$
 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: $As_{mid} = 307.8761$
 Mean Diameter of Tension Reinforcement, $Db_L = 14.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.02653457$
 $u = y + p = 0.03121714$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00121714$ ((4.29), Biskinis Phd))
 $M_y = 5.7023\text{E}+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 646.0505
 From table 10.5, ASCE 41_17: $E_{eff} = 0.3 * E_c * I_g = 1.0089\text{E}+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.8184688\text{E}-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 248.9669$
 $d = 358.00$
 $y = 0.27836167$
 $A = 0.01423774$
 $B = 0.0080349$
 with $p_t = 0.00573326$
 $p_c = 0.00561626$
 $p_v = 0.00286663$
 $N = 577.3164$
 $b = 300.00$
 $" = 0.12011173$
 $y_{comp} = 1.7202837\text{E}-005$
 with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.27810356$
 $A = 0.01420045$
 $B = 0.00801331$
 with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of p -

From table 10-7: $p = 0.03$
 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 $V_p/V_o = 0.40051388$

- Transverse Reinforcement: NC

- Stirrup Spacing $> d/3$

- Low ductility demand, $\lambda / y < 2$ (table 10-6, ASCE 41-17)

$= 2.5010211E-005$

- Stirrup Spacing $\leq d/2$

$d = 358.00$

$s = 150.00$

- Strength provided by hoops $V_s < 3/4 \cdot \text{design Shear}$

$V_s = 148934.763$, already given in calculation of shear control ratio

design Shear = 8686.46

- ($\lambda - y$)/ bal = -0.14721673

$= A_{sl}/(b_w \cdot d) = 0.00573326$

Tension Reinf Area: $A_{sl} = 615.7522$

$\lambda = A_{sl}/(b_w \cdot d) = 0.00848289$

Compression Reinf Area: $A_{slc} = 911.0619$

From (B-1), ACI 318-11: bal = 0.01867739

$f_c = 20.00$

$f_y = 444.4444$

From 10.2.7.3, ACI 318-11: $\lambda = 0.85$

From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + y) = 0.57446809$

$y = 0.00222222$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 0.21779444$, 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

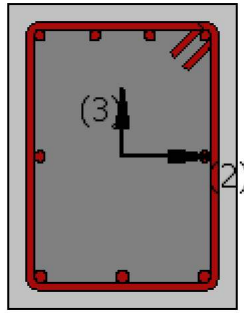
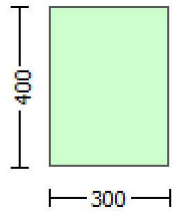
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor, $\phi = 0.85$

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

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

Consequently:

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

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups 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, $M_a = 5.3886E+006$

Shear Force, $V_a = -3205.931$

EDGE -B-

Bending Moment, $M_b = 5.6119E+006$

Shear Force, $V_b = 8686.46$

BOTH EDGES

Axial Force, $F = -577.3164$

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: $As_{l,com} = 603.1858$

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

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 14.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = *V_n = 170566.239$

$V_n ((22.5.1.1), ACI 318-14) = 200666.163$

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: $V_c = 66624.876$

= 1 (normal-weight concrete)

$f'_c = 16.00$, 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

$b_w = 300.00$

$d = 320.00$

$V_u * d / M_u < 1 = 0.49531735$

$M_u = 5.6119E+006$

$V_u = 8686.46$

From (11.5.4.8), ACI 318-14: $V_s = 134041.287$

$A_v = 157079.633$

$f_y = 400.00$

$s = 150.00$

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: $V_s + V_f \leq 255092.67$

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

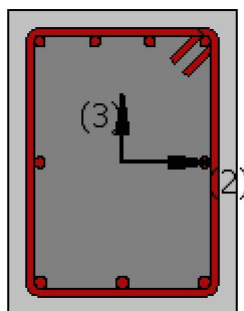
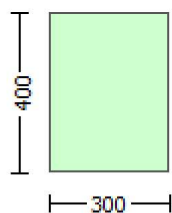
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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, $F = -224.0408$

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: $As_{l,com} = 615.7522$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.40051388$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 91269.476$

with $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.1931E+007$

$\mu_{u1+} = 8.0426E+007$, 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

$\mu_{u1-} = 8.1931E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.1848E+007$

$\mu_{u2+} = 8.0508E+007$, 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

$\mu_{u2-} = 8.1848E+007$, 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

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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 1.7898746E-005$$

$$M_u = 8.0426E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$\nu = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } s_{u1_nominal} = 0.08,$$

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_s/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$s_{u2} = 0.00512$$

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
 $l_o/l_{o,min} = l_b/l_{b,min} = 0.30$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $suv = 0.00512$
 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 y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Es_v = Es = 200000.00$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.08763615$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.08946191$
 $v = A_{sl,mid}/(b * d) * (fsv/f_c) = 0.04473095$
 and confined core properties:
 $b = 240.00$
 $d = 327.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.11959521$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.12208678$
 $v = A_{sl,mid}/(b * d) * (fsv/f_c) = 0.06104339$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.19872953$
 $Mu = MR_c (4.14) = 8.0426E+007$
 $u = su (4.1) = 1.7898746E-005$

 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:

$$u = 1.7900352E-005$$

$$Mu = 8.1931E+007$$

 with full section properties:

$$b = 300.00$$

$$d = 358.00$$

```

d' = 43.00
v = 0.0001043
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00
ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799
-----
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 = 555.5556
fce = 20.00
From ((5A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 $fsyv = fsv/1.2$, 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.08921201$
 $2 = Asl_{com}/(b*d) * (fs2/fc) = 0.08739136$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.04460601$
 and confined core properties:
 $b = 240.00$
 $d = 328.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.12171456$
 $2 = Asl_{com}/(b*d) * (fs2/fc) = 0.11923059$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.06085728$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.20103941$
 $Mu = MRc (4.14) = 8.1931E+007$
 $u = su (4.1) = 1.7900352E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of $Mu2+$

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

$u = 1.7861306E-005$
 $Mu = 8.0508E+007$

with full section properties:

$b = 300.00$
 $d = 358.00$
 $d' = 43.00$
 $v = 0.0001043$
 $N = 224.0408$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00777035$
 $we (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

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 = 555.5556
 fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.00292176
 c = confinement factor = 1.09218

y1 = 0.0012967
 sh1 = 0.0044814
 ft1 = 373.4504
 fy1 = 311.2087
 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*esu1_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = fs = 311.2087

with Es1 = Es = 200000.00

y2 = 0.0012967
 sh2 = 0.0044814
 ft2 = 373.4504
 fy2 = 311.2087
 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,min)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = fs = 311.2087

with Es2 = Es = 200000.00

yv = 0.0012967
 shv = 0.0044814
 ftv = 373.4504
 fyv = 311.2087
 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,min = 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/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08739136

2 = Asl,com/(b*d)*(fs2/fc) = 0.08921201

v = Asl,mid/(b*d)*(fsv/fc) = 0.04460601

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$fcc(5A.2, TBDY) = 21.84352$$

$$cc(5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.11923059$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.12171456$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.06085728$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$su(4.9) = 0.19929283$$

$$Mu = MRc(4.14) = 8.0508E+007$$

$$u = su(4.1) = 1.7861306E-005$$

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:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$fc = 20.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00777035$$

$$w_e(5.4c) = 0.01139744$$

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

$$bo = 240.00$$

$$ho = 340.00$$

$$bi2 = 346400.00$$

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

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 300.00$$

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

```

y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
    with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191
2 = Asl,com/(b*d)*(fs2/fc) = 0.08763615
v = Asl,mid/(b*d)*(fsv/fc) = 0.04473095
and confined core properties:
b = 240.00
d = 327.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.12208678
2 = Asl,com/(b*d)*(fs2/fc) = 0.11959521
v = Asl,mid/(b*d)*(fsv/fc) = 0.06104339
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->

```


$\phi_u (4.9) = 0.20048836$
 $\phi_{uR} = \phi_{uRc} (4.14) = 8.1848E+007$
 $\phi_u = \phi_u (4.1) = 1.7938121E-005$

Calculation of ratio ϕ_b/ϕ_d

Inadequate Lap Length with $\phi_b/\phi_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 227880.93$

Calculation of Shear Strength at edge 1, $V_{r1} = 227880.93$
 $V_{r1} = V_n ((22.5.1.1), \text{ACI } 318-14)$

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: $V_c = 78946.167$
= 1 (normal-weight concrete)
 $f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $\rho_w = A_s/(b_w*d) = 0.00628319$
 A_s (tension reinf.) = 603.1858
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\phi_{uR} < 1 = 1.00$
 $\phi_{uR} = 6709.869$
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$
 $A_v = 157079.633$
 $f_y = 444.4444$
 $s = 150.00$

V_s has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 227880.93$
 $V_{r2} = V_n ((22.5.1.1), \text{ACI } 318-14)$

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: $V_c = 78946.167$
= 1 (normal-weight concrete)
 $f'_c = 20.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $\rho_w = A_s/(b_w*d) = 0.00628319$
 A_s (tension reinf.) = 603.1858
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\phi_{uR} < 1 = 1.00$
 $\phi_{uR} = 6709.869$
 $V_u = 2740.264$

From (11.5.4.8), ACI 318-14: $V_s = 148934.763$
 $A_v = 157079.633$
 $f_y = 444.4444$
 $s = 150.00$

V_s has been multiplied by 1 ($s < d/2$, according to ASCE 41-17, 10.3.4)
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$

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

Consequently:

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Section Height, $H = 400.00$

Section Width, $W = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09218

Element Length, $L = 1850.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 4.9175078E-016$

EDGE -B-

Shear Force, $V_b = -4.9175078E-016$

BOTH EDGES

Axial Force, $F = -224.0408$

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: $A_{sl,ten} = 508.938$

-Compression: $A_{sl,com} = 508.938$

-Middle: $A_{sl,mid} = 508.938$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.37910917$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u \cdot l_n/2 = 57801.946$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 5.3467E+007$

$\mu_{u1+} = 5.3467E+007$, 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

$\mu_{u1-} = 5.3467E+007$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 5.3467E+007$

$\mu_{u2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 5.3467E+007$, 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 = 4.9175078E-016, is the shear force acting at edge 1 for the the static loading combination

V2 = -4.9175078E-016, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu1+

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

$$\phi_u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00777035$$

$$\phi_{we} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $s_{u1_nominal} = 0.08$,

For calculation of $s_{u1_nominal}$ and y_1 , sh_1 , f_{t1} , f_{y1} , it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

```

ft2 = 373.4504
fy2 = 311.2087
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/lo,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 = 311.2087
    with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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/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 Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-005

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu1-

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

u = 2.5362472E-005
Mu = 5.3467E+007

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_c: \phi_c = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00777035$$

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

$$\text{From (5.4b), TBDY: } \phi_c = 0.00777035$$

$$\phi_w (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = fs_1/1.2$, 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.

$$\text{with } fs_1 = fs = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4504$$

$$f_{y2} = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

For calculation of $esu_{2,nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = fs_2/1.2$, 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.

$$\text{with } fs_2 = fs = 311.2087$$

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

$$y_v = 0.0012967$$

```

shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = fs = 311.2087
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
    c = confinement factor = 1.09218
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
    v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.21754625
Mu = MRc (4.14) = 5.3467E+007
u = su (4.1) = 2.5362472E-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 = 2.5362472E-005
Mu = 5.3467E+007

```

with full section properties:

```

b = 400.00
d = 258.00
d' = 42.00
v = 0.00010855
N = 224.0408
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00777035
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00777035
we (5.4c) = 0.01139744
ase ((5.4d), TBDY) = 0.15672608
bo = 240.00

```

ho = 340.00
bi2 = 346400.00
psh,min = Min(psh,x , psh,y) = 0.00261799

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 = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 311.2087

with $E_s = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07673736$
and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.21754625$
 $Mu = MR_c (4.14) = 5.3467E+007$
 $u = su (4.1) = 2.5362472E-005$

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:
 $u = 2.5362472E-005$
 $Mu = 5.3467E+007$

with full section properties:

$b = 400.00$
 $d = 258.00$
 $d' = 42.00$
 $v = 0.00010855$
 $N = 224.0408$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00777035$
 $w_e (5.4c) = 0.01139744$
 $ase ((5.4d), TBDY) = 0.15672608$
 $bo = 240.00$
 $ho = 340.00$
 $bi2 = 346400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

 $psh,x (5.4d) = 0.00349066$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 300.00$

$psh,y (5.4d) = 0.00261799$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 400.00$

$s = 150.00$


```

fywe = 555.5556
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.00292176
c = confinement factor = 1.09218
y1 = 0.0012967
sh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
y2 = 0.0012967
sh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
yv = 0.0012967
shv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736
2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736
v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736
and confined core properties:
b = 340.00
d = 228.00
d' = 12.00
fcc (5A.2, TBDY) = 21.84352
cc (5A.5, TBDY) = 0.00292176
c = confinement factor = 1.09218
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1021581
2 = Asl,com/(b*d)*(fs2/fc) = 0.1021581
v = Asl,mid/(b*d)*(fsv/fc) = 0.1021581
Case/Assumption: Unconfinedsd full section - Steel rupture

```

satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.21754625

$\mu_u = M_{Rc}$ (4.14) = 5.3467E+007

$u = \mu_u$ (4.1) = 2.5362472E-005

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 152467.812$

Calculation of Shear Strength at edge 1, $V_{r1} = 152467.812$

$V_{r1} = V_n$ ((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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f'_c = 20.00$, 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

$b_w = 400.00$

$d = 240.00$

$V_u*d/\mu_u < 1 = 0.00$

$\mu_u = 1.0885753E-012$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$V_{r2} = V_n$ ((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: $V_c = 68692.008$

= 1 (normal-weight concrete)

$f'_c = 20.00$, 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

$b_w = 400.00$

$d = 240.00$

$V_u*d/\mu_u < 1 = 0.00$

$\mu_u = 1.7913670E-013$

$V_u = 4.9175078E-016$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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: $V_s + V_f \leq 285202.276$

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, $\phi = 0.85$
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:
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups 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, $M = -2.1868695E-011$
Shear Force, $V_2 = 1.0034397E-014$
Shear Force, $V_3 = 8686.46$
Axial Force, $F = -577.3164$
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, $Db_L = 14.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \phi \cdot u = 0.02727624$
 $u = y + p = 0.03208969$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00208969$ ((4.29), Biskinis Phd))
 $M_y = 3.8463E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 925.00
From table 10.5, ASCE 41_17: $E_{eff} = 0.3 \cdot E_c \cdot I_g = 5.6751E+012$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 6.7762196\text{E-}006$
with $((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 248.9669$
 $d = 258.00$
 $y = 0.28795984$
 $A = 0.01481718$
 $B = 0.00862404$
with $p_t = 0.00493157$
 $p_c = 0.00493157$
 $p_v = 0.00493157$
 $N = 577.3164$
 $b = 400.00$
 $\mu = 0.1627907$
 $y_{\text{comp}} = 2.3073663\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.28770896$
 $A = 0.01477838$
 $B = 0.00860158$
with $E_s = 200000.00$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of ϕ_p -

From table 10-7: $\phi_p = 0.03$

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 $V_p/V_o = 0.37910917$
- Transverse Reinforcement: NC
- Stirrup Spacing $> d/3$
- Low ductility demand, $\phi_y < 2$ (table 10-6, ASCE 41-17)
 $\phi_y = -6.0732723\text{E-}022$
- Stirrup Spacing $> d/2$
 $d = 258.00$
 $s = 150.00$
- Strength provided by hoops $V_s < 3/4 \cdot \text{design Shear}$
 $V_s = 111701.072$, already given in calculation of shear control ratio
design Shear = $1.0034397\text{E-}014$
- ($\phi_c - \phi_y$)/ $\phi_{bal} = -0.15320811$
 $\phi_c = A_{st}/(b_w \cdot d) = 0.00596659$
Tension Reinf Area: $A_{st} = 615.7522$
 $\phi_y = A_{sc}/(b_w \cdot d) = 0.00882812$
Compression Reinf Area: $A_{sc} = 911.0619$
From (B-1), ACI 318-11: $\phi_{bal} = 0.01867739$
 $f_c = 20.00$
 $f_y = 444.4444$
From 10.2.7.3, ACI 318-11: $\phi_1 = 0.85$
From fig R10.3.3, ACI 318-11 (Ence 454, too): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \phi_y) = 0.57446809$
 $\phi_y = 0.00222222$
- $V/(b_w \cdot d \cdot f_c^{0.5}) = 2.6183026\text{E-}019$, 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)
