

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

beam B1, Floor 1

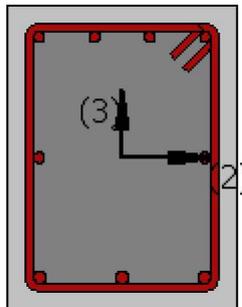
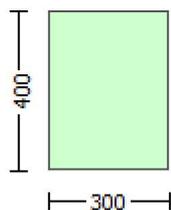
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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 $l_o/l_{o,min} = l_b/l_d = 0.30$
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: $A_{s,t} = 603.1858$
-Compression: $A_{s,c} = 923.6282$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 508.938$
-Compression: $A_{s,com} = 508.938$
-Middle: $A_{s,mid} = 508.938$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 14.66667$

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

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

From Table (22.5.5.1), ACI 318-14: $V_c = 61440.00$
= 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
 $b_w = 400.00$
 $d = 240.00$
 $V_u*d/M_u < 1 = 0.00$
 $M_u = 2.8524885E-012$
 $V_u = 7.9210123E-015$
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

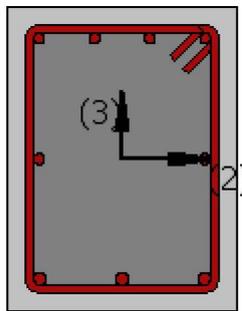
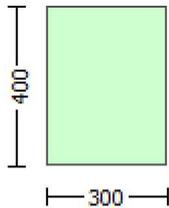
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor, $\phi = 0.85$

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: $As_{c,com} = 615.7522$

-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 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 the static loading combination

and

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

with

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

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

Calculation of Mu_{1+}

Calculation of ultimate curvature 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_c (5A.5, TBDY) = 0.002

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

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

$b_o = 240.00$

$h_o = 340.00$

$bi_2 = 346400.00$

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

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

$$\text{Ash} = \text{Astir} * ns = 78.53982$$

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

$$bk = 300.00$$

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

$$\text{Ash} = \text{Astir} * ns = 78.53982$$

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

$$bk = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

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

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

$$y1 = 0.0012967$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4504$$

$$fy1 = 311.2087$$

$$su1 = 0.00512$$

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

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

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

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

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

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

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

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

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

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

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

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

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

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

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

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.

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

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

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

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

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.08946191$$

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

and confined core properties:

$$b = 240.00$$

$$d = 327.00$$

$$d' = 12.00$$

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

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

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

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

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.12208678$$

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

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 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:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

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

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

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

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

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

with $fsv = fs = 311.2087$

with $Esv = Es = 200000.00$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.08921201$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.08739136$

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

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)

--->

$v < v_s, y_2$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.20103941$$

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

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of $M_u/2+$

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

$$u = 1.7861306E-005$$

$$M_u = 8.0508E+007$$

with full section properties:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e(5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

No stirups, $n_s = 2.00$

$$b_k = 300.00$$

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

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

No stirups, $n_s = 2.00$

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

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

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

with $fs_1 = fs = 311.2087$

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

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

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

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 $Es_2 = Es = 200000.00$

$y_v = 0.0012967$

$sh_v = 0.0044814$

$ft_v = 373.4504$

$fy_v = 311.2087$

$su_v = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

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

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

with $fs_v = fs = 311.2087$

with $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.08739136$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.08921201$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.04460601$

and confined core properties:

$b = 240.00$

$d = 328.00$

$d' = 13.00$

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

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

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11923059$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.12171456$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.06085728$

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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7938121E-005$$

$$Mu = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e(5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * e_{su1_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{su1_nominal} = 0.08,$$

For calculation of $e_{su1_nominal}$ 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

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

$$s_{u2} = 0.4 * e_{su2_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{su2_nominal} = 0.08,$$

For calculation of $e_{su2_nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered

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

y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s2} = f_s = 311.2087$

with $E_{s2} = E_s = 200000.00$

$y_v = 0.0012967$

$sh_v = 0.0044814$

$ft_v = 373.4504$

$f_{y_v} = 311.2087$

$s_{u_v} = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

For calculation of $e_{s_{u_v,nominal}}$ and y_v, sh_v, ft_v, f_{y_v} , it is considered

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

y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s_v} = f_s = 311.2087$

with $E_{s_v} = E_s = 200000.00$

1 = $A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.08946191$

2 = $A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08763615$

v = $A_{s1,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.04473095$

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 = confinement factor = 1.09218

1 = $A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12208678$

2 = $A_{s1,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11959521$

v = $A_{s1,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.06104339$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

s_u (4.9) = 0.20048836

$\mu_u = M_{Rc}$ (4.14) = 8.1848E+007

u = s_u (4.1) = 1.7938121E-005

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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

Calculation of Shear Strength at edge 1, $V_{r1} = 227880.93$

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

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

From Table (22.5.5.1), ACI 318-14: $V_c = 78946.167$

= 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

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

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: Vs + Vf <= 285202.276

Calculation of Shear Strength at edge 2, Vr2 = 227880.93

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

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

From Table (22.5.5.1), ACI 318-14: Vc = 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: Vs + Vf <= 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, = 0.85

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

Consequently:

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

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

Existing material: Steel Strength, fs = 1.25*fsm = 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: $As_t = 603.1858$
-Compression: $As_c = 923.6282$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 508.938$
-Compression: $As_{c,com} = 508.938$
-Middle: $As_{c,mid} = 508.938$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.37910917$
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
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 5.3467E+007$
 $\mu_{u1+} = 5.3467E+007$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 5.3467E+007$
 $\mu_{u2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the 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
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
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 μ_{u1+}

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

with full section properties:

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

ase ((5.4d), TBDY) = 0.15672608
bo = 240.00
ho = 340.00
bi2 = 346400.00
psh,min = 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.

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

with $f_{sv} = f_s = 311.2087$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.07673736$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07673736$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07673736$

and confined core properties:

$b = 340.00$

$d = 228.00$

$d' = 12.00$

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

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

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.1021581$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.1021581$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su \text{ (4.9)} = 0.21754625$

$Mu = MRc \text{ (4.14)} = 5.3467E+007$

$u = su \text{ (4.1)} = 2.5362472E-005$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Mu_1 -

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

$u = 2.5362472E-005$

$Mu = 5.3467E+007$

with full section properties:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 0.00010855$

$N = 224.0408$

$f_c = 20.00$

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

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: $cu = 0.00777035$

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

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

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

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

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

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

No stirups, $ns = 2.00$

$bk = 300.00$

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

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

No stirups, $ns = 2.00$

$bk = 400.00$

$s = 150.00$
 $fy_{we} = 555.5556$
 $f_{ce} = 20.00$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = fs = 311.2087$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 311.2087$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.07673736$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.07673736$
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.07673736$
 and confined core properties:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 21.84352$
 $cc \text{ (5A.5, TBDY)} = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.1021581$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.1021581$

$$v = A_s l_{mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.1021581$$

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 l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e(5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

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

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

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

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

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

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.30$$

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

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

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

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

$$y_v = 0.0012967$$

$$sh_v = 0.0044814$$

$$ft_v = 373.4504$$

$$fy_v = 311.2087$$

$$su_v = 0.00512$$

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

$$lo/lou, \text{min} = lb/ld = 0.30$$

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

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

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

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

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.07673736$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.07673736$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.07673736$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.1021581$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.1021581$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.1021581$$

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 Mu2-

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

$$u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

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

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_v = 0.0012967$$

$$sh_v = 0.0044814$$

$$ft_v = 373.4504$$

$$fy_v = 311.2087$$

$$s_{uv} = 0.00512$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

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

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.07673736$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.07673736$$

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

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

--->

$$s_u (4.9) = 0.21754625$$

$$M_u = MR_c (4.14) = 5.3467E+007$$

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

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

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

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

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

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

As (tension reinf.) = 603.1858

bw = 400.00

d = 240.00

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

$\mu = 1.0885753E-012$

$V_u = 4.9175078E-016$

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

$A_v = 157079.633$

$f_y = 444.4444$

$s = 150.00$

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) '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)

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

As (tension reinf.) = 603.1858

bw = 400.00

d = 240.00

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

$\mu = 1.7913670E-013$

$V_u = 4.9175078E-016$

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: 2

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, $M = 4.3080E+006$

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: $As_{c,mid} = 307.8761$

Mean Diameter of Tension Reinforcement, $Db_L = 16.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = \phi \cdot u = 0.00761144$

$u = y + p = 0.00895463$

- Calculation of y -

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

$M_y = 5.5905E+007$

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

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

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

$y_{ten} = 4.8148274E-006$

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

$d = 357.00$

$y = 0.27579298$

$A = 0.01427496$

$B = 0.0079338$

with $p_t = 0.00563199$

$p_c = 0.00574932$

$p_v = 0.00287466$

$N = 506.3875$

$b = 300.00$

$\mu = 0.11764706$

$y_{comp} = 1.7410083E-005$

with $f_c = 20.00$

$E_c = 21019.039$

$y = 0.27556281$

$A = 0.01424216$

$B = 0.00791481$

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 $V_s < 3/4 \cdot \text{design Shear}$

$$V_s = 148934.763, \text{ already given in calculation of shear control ratio}$$

$$\text{design Shear} = 2012.085$$

- ($\lambda - 1$)/ λ bal = -0.16019328

$$= A_{st}/(b_w \cdot d) = 0.00563199$$

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

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

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

From (B-1), ACI 318-11: λ bal = 0.01867739

$$f_c = 20.00$$

$$f_y = 444.4444$$

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

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

$$y = 0.00222222$$

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

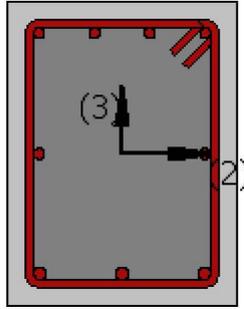
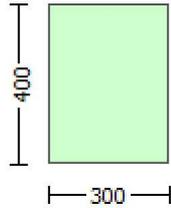
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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: $A_{sl,t} = 603.1858$

-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: $A_{sl,mid} = 307.8761$

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
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\mu < 1 = 0.1494578$
 $\mu = 4.3080E+006$
 $V_u = 2012.085$
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

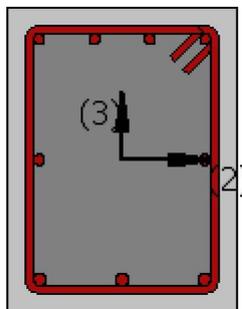
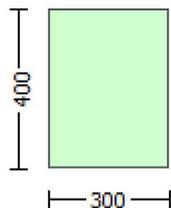
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (3)



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

Section Type: rcars

Constant Properties

Knowledge Factor, $\phi = 0.85$

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: 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

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

$M_{u1+} = 8.0426E+007$, 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

$M_{u1-} = 8.1931E+007$, 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

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

$M_{u2+} = 8.0508E+007$, 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

$M_{u2-} = 8.1848E+007$, 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:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

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

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = fs = 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*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, TBDY) = 21.84352

cc (5A.5, TBDY) = 0.00292176

c = confinement factor = 1.09218

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11959521

2 = Asl,com/(b*d)*(fs2/fc) = 0.12208678

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) = 0.19872953

Mu = MRc (4.14) = 8.0426E+007

u = su (4.1) = 1.7898746E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

u = 1.7900352E-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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
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 = 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/d = 0.30
su1 = $0.4 * \text{esu1_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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 = $0.4 * \text{esu2_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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

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

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

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

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

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

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

with $f_{sv} = f_s = 311.2087$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.08921201$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.08739136$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04460601$

and confined core properties:

$b = 240.00$

$d = 328.00$

$d' = 13.00$

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

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

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

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.12171456$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.11923059$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06085728$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$s_u (4.9) = 0.20103941$

$M_u = MR_c (4.14) = 8.1931E+007$

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

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

$u = 1.7861306E-005$

$M_u = 8.0508E+007$

with full section properties:

$b = 300.00$

$d = 358.00$

$d' = 43.00$

$v = 0.0001043$

$N = 224.0408$

$f_c = 20.00$

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

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: $cu = 0.00777035$

$w_e (5.4c) = 0.01139744$

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

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

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

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.A.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) = 0.08739136

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

--->

$$s_u (4.9) = 0.19929283$$

$$M_u = MR_c (4.14) = 8.0508E+007$$

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u2 -

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

$$u = 1.7938121E-005$$

$$M_u = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

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

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191

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

--->

su (4.9) = 0.20048836
Mu = MRc (4.14) = 8.1848E+007
u = su (4.1) = 1.7938121E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 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 <= 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: Vs + Vf <= 285202.276

Calculation of Shear Strength at edge 2, Vr2 = 227880.93
Vr2 = Vn ((22.5.1.1), ACI 318-14)

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

From Table (22.5.5.1), ACI 318-14: Vc = 78946.167
= 1 (normal-weight concrete)
fc' = 20.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
pw = As/(bw*d) = 0.00628319
As (tension reinf.) = 603.1858
bw = 300.00
d = 320.00
Vu*d/Mu < 1 = 1.00
Mu = 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: Vs + Vf <= 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

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

$M_{u1+} = 5.3467E+007$, 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

$M_{u1-} = 5.3467E+007$, 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

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

$M_{u2+} = 5.3467E+007$, 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

$M_{u2-} = 5.3467E+007$, 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:

$$u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$fc = 20.00$$

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

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

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

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

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

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

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

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

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

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.

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

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

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

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

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

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

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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 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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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, $n_s = 2.00$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of $esu1_{nominal}$ and y_1, sh_1, 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, 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

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

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

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

For calculation of $esu2_{nominal}$ and y_2, sh_2, 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, 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 $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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 u according to 4.1, Biskinis/Fardis 2013:

$$u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$fc = 20.00$$

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

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

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

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

$$we (5.4c) = 0.01139744$$

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

$$bo = 240.00$$

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/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 $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$$

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

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.21754625$$

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

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

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.

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

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

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

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

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

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

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

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

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

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

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.21754625$$

$$M_u = MR_c(4.14) = 5.3467E+007$$

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

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, $V_{r1} = 152467.812$

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

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).

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

= 1 (normal-weight concrete)

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

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

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

$$b_w = 400.00$$

$$d = 240.00$$

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

$$M_u = 1.0885753E-012$$

$$V_u = 4.9175078E-016$$

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

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

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

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

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

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

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

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).

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

= 1 (normal-weight concrete)

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

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

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

$$b_w = 400.00$$

$$d = 240.00$$

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

$$M_u = 1.7913670E-013$$

$$V_u = 4.9175078E-016$$

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

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

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

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

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

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: 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: $A_{st} = 603.1858$
-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 $u_{,R} = \phi \cdot u = 0.00602588$
 $u = y + p = 0.00708927$

- 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 -

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

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

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

$$d = 258.00$$

$$y = 0.28791623$$

$$A = 0.01481442$$

$$B = 0.00862128$$

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

$$p_c = 0.00493157$$

$$p_v = 0.00493157$$

$$N = 506.3875$$

$$b = 400.00$$

$$" = 0.1627907$$

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

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

$$E_c = 21019.039$$

$$y = 0.28769614$$

$$A = 0.01478038$$

$$B = 0.00860158$$

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

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 = $7.9210123\text{E-}015$

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

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

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

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

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

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

$$f_c = 20.00$$

$$f_y = 444.4444$$

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

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

$$\phi_y = 0.00222222$$

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

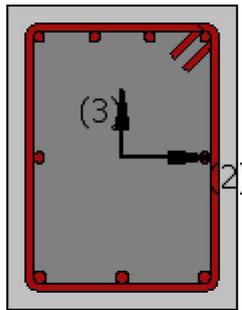
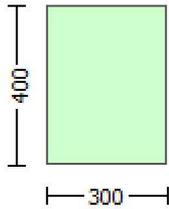
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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 $l_o/l_{ou,min} = l_b/d = 0.30$
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: $A_{st} = 615.7522$

-Compression: $A_{sc} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{s,ten} = 508.938$

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

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

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 14.66667$

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)

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

A_s (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

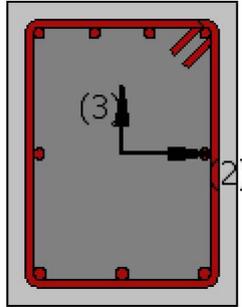
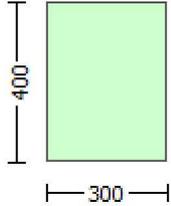
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 2740.264$

EDGE -B-

Shear Force, $V_b = 2740.264$
BOTH EDGES
Axial Force, $F = -224.0408$
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: $As_{,ten} = 603.1858$
-Compression: $As_{,com} = 615.7522$
-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 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u * l_n / 2 = 91269.476$
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 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 the static loading combination
and
 $\pm w_u * l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 2740.264$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = 2740.264$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature 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_c (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00777035$
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
 $b_o = 240.00$
 $h_o = 340.00$
 $bi_2 = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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

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

with fsv = fs = 311.2087

with Esv = Es = 200000.00

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

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, TBDY) = 21.84352

cc (5A.5, TBDY) = 0.00292176

c = confinement factor = 1.09218

1 = $Asl,ten/(b*d)*(fs1/fc) = 0.11959521$

2 = $Asl,com/(b*d)*(fs2/fc) = 0.12208678$

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) = 0.19872953

Mu = MRc (4.14) = 8.0426E+007

u = su (4.1) = 1.7898746E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/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

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/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) = 0.08921201

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 = 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 lb/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:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

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

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_v = 0.0012967$$

$$sh_v = 0.0044814$$

$$ft_v = 373.4504$$

$$fy_v = 311.2087$$

$$s_{uv} = 0.00512$$

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

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

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.08739136$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.08921201$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04460601$$

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.11923059$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.12171456$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06085728$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.19929283$$

$$\mu_u = M_{Rc} (4.14) = 8.0508E+007$$

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

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

$$u = 1.7938121E-005$$

$$\mu_u = 8.1848E+007$$

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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
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 = $\text{Astir} * ns = 78.53982$
No stirups, ns = 2.00
bk = 300.00

psh,y (5.4d) = 0.00261799
Ash = $\text{Astir} * ns = 78.53982$
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
 $lo/lou,min = lb/d = 0.30$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu1_nominal = 0.08$,
For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191

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

su (4.9) = 0.20048836

Mu = MRc (4.14) = 8.1848E+007

u = su (4.1) = 1.7938121E-005

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 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) '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: $V_c = 78946.167$
= 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

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

$M_{u1+} = 5.3467E+007$, 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

$M_{u1-} = 5.3467E+007$, 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

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

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

$M_{u2-} = 5.3467E+007$, 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

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

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 M_{u1+}

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:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 0.00010855$

$N = 224.0408$

$f_c = 20.00$

ω (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

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

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

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

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

No stirrups, ns = 2.00
bk = 300.00

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

s = 150.00
fywe = 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/d = 0.30

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

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

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

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

with fs1 = fs = 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 = $Asl,mid/(b*d)*(fsv/fc)$ = 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/l_d

Inadequate Lap Length with lb/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
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

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

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

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

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

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

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

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

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

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

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

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

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

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

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

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

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

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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

--->

$$su (4.9) = 0.21754625$$

$$Mu = MRc (4.14) = 5.3467E+007$$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

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

$$u = 2.5362472E-005$$

$$\mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$\mu_{cc} \text{ (5.4c)} = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

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

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

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.

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

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

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

$$y_2 = 0.0012967$$

$sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
 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
 $lo/lo_{min} = lb/lb_{min} = 0.30$
 $su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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.
 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:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.1021581$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.1021581$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - 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 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

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 = $\text{Astir} * ns = 78.53982$

No stirups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = $\text{Astir} * ns = 78.53982$

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 = $lb/d = 0.30$

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

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

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

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

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

with $fs2 = fs = 311.2087$

with $Es2 = Es = 200000.00$

$y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $su_v = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{min} = lb/ld = 0.30$
 $su_v = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_y = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_y = fsv/1.2$, 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) '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)
 $fc' = 20.00$, 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
 $bw = 400.00$
 $d = 240.00$
 $Vu*d/Mu < 1 = 0.00$
 $Mu = 1.0885753E-012$
 $Vu = 4.9175078E-016$
 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) '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)

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

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

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

$$b_w = 400.00$$

$$d = 240.00$$

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

$$M_u = 1.7913670E-013$$

$$V_u = 4.9175078E-016$$

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

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

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, $M = 4.4838E+006$
Shear Force, $V2 = 7.9210123E-015$
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 -

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

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

Inadequate Lap Length with $l_b / d = 0.30$

- Calculation of p -

From table 10-7: $p = 0.005$
with:
- Condition iv occurred

Beam controlled by inadequate embedment into beam-column joint:

($b/d < 1$ and With Lapping in the Vicinity of the End Regions

- Condition i occurred

Beam controlled by flexure: $V_p/V_o \leq 1$

shear control ratio $V_p/V_o = 0.40051388$

- Transverse Reinforcement: NC

- Stirrup Spacing $> d/3$

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

$\lambda = 1.5475464E-005$

- 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

- ($\lambda - 1$)/ $\lambda = -0.14721673$

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

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): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \lambda) = 0.57446809$

$\lambda = 0.00222222$

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

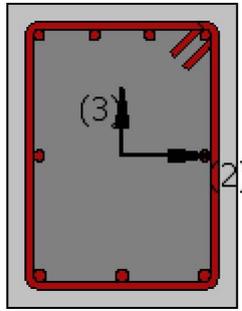
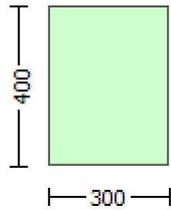
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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: $A_{sl,ten} = 615.7522$

-Compression: $A_{sl,com} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 615.7522$

-Compression: $A_{sl,com} = 603.1858$

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

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 14.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 170916.926$

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

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)
 $\rho_w = A_s/(b_w*d) = 0.00641409$
 A_s (tension reinf.) = 615.7522
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\mu < 1 = 0.53473099$
 $\mu = 4.4838E+006$
 $V_u = 7492.614$
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 ($s < d/2$, 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

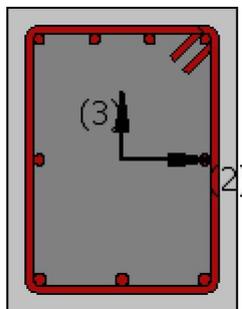
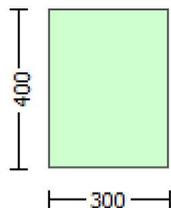
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (3)



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

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 2740.264$

EDGE -B-

Shear Force, $V_b = 2740.264$

BOTH EDGES

Axial Force, $F = -224.0408$

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

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

$M_{u1+} = 8.0426E+007$, 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

$M_{u1-} = 8.1931E+007$, 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

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

$M_{u2+} = 8.0508E+007$, 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

$M_{u2-} = 8.1848E+007$, 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:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

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

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = fs = 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*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, TBDY) = 21.84352

cc (5A.5, TBDY) = 0.00292176

c = confinement factor = 1.09218

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11959521

2 = Asl,com/(b*d)*(fs2/fc) = 0.12208678

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) = 0.19872953

Mu = MRc (4.14) = 8.0426E+007

u = su (4.1) = 1.7898746E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

u = 1.7900352E-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 ((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/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

$l_0/l_{0u,min} = l_b/d = 0.30$

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

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

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

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

γ_1 , sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 311.2087$

with $E_{sv} = E_s = 200000.00$

1 = $Asl_{ten}/(b*d) * (f_{s1}/f_c) = 0.08921201$

2 = $Asl_{com}/(b*d) * (f_{s2}/f_c) = 0.08739136$

$v = Asl_{mid}/(b*d) * (f_{sv}/f_c) = 0.04460601$

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 = $Asl_{ten}/(b*d) * (f_{s1}/f_c) = 0.12171456$

2 = $Asl_{com}/(b*d) * (f_{s2}/f_c) = 0.11923059$

$v = Asl_{mid}/(b*d) * (f_{sv}/f_c) = 0.06085728$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$s_u (4.9) = 0.20103941$

$M_u = MR_c (4.14) = 8.1931E+007$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_{u2+}

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

$u = 1.7861306E-005$

$M_u = 8.0508E+007$

with full section properties:

$b = 300.00$

$d = 358.00$

$d' = 43.00$

$v = 0.0001043$

$N = 224.0408$

$f_c = 20.00$

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

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: $cu = 0.00777035$

$w_e (5.4c) = 0.01139744$

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

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

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

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.A.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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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*esu2_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs2 = fs = 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*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

--->

$$s_u (4.9) = 0.19929283$$

$$M_u = MR_c (4.14) = 8.0508E+007$$

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u2 -

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

$$u = 1.7938121E-005$$

$$M_u = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

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

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191

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

--->

su (4.9) = 0.20048836
Mu = MRc (4.14) = 8.1848E+007
u = su (4.1) = 1.7938121E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 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 <= 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: Vs + Vf <= 285202.276

Calculation of Shear Strength at edge 2, Vr2 = 227880.93
Vr2 = Vn ((22.5.1.1), ACI 318-14)

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

From Table (22.5.5.1), ACI 318-14: Vc = 78946.167
= 1 (normal-weight concrete)
fc' = 20.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
pw = As/(bw*d) = 0.00628319
As (tension reinf.) = 603.1858
bw = 300.00
d = 320.00
Vu*d/Mu < 1 = 1.00
Mu = 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: Vs + Vf <= 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

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

$M_{u1+} = 5.3467E+007$, 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

$M_{u1-} = 5.3467E+007$, 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

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

$M_{u2+} = 5.3467E+007$, 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

$M_{u2-} = 5.3467E+007$, 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:

$$u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$fc = 20.00$$

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

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

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

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

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

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

For calculation of $\phi_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered

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

$$\text{with } \phi_{s1} = \phi_s = 311.2087$$

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

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

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

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.

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

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

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

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

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

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

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736$$

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 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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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, $n_s = 2.00$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4504$$

$$f_{y1} = 311.2087$$

$$s_{u1} = 0.00512$$

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

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

$$s_{u1} = 0.4 * e_{s1_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s1_nominal} = 0.08,$$

For calculation of $e_{s1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, 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

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

$$s_{u2} = 0.4 * e_{s2_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s2_nominal} = 0.08,$$

For calculation of $e_{s2_nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

$y_2, sh_2, f_{t2}, f_{y2}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

$$y_v = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

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

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.07673736$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.07673736$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07673736$$

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 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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$fc = 20.00$$

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

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

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

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

$$we (5.4c) = 0.01139744$$

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

$$bo = 240.00$$

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/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 $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$$

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

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$$

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.21754625$$

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

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{u2}

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

$$u = 2.5362472E-005$$

$$\mu_u = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

$$w_e (5.4c) = 0.01139744$$

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

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

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

$$y1 = 0.0012967$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4504$$

$$fy1 = 311.2087$$

$$su1 = 0.00512$$

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

$$lo/lou, \text{min} = lb/ld = 0.30$$

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

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

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

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

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

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

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.30$$

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

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

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

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

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

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

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

$$lo/lou, \text{min} = lb/ld = 0.30$$

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

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

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.

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.07673736$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

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

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.1021581$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.1021581$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.1021581$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.21754625$$

$$M_u = MR_c(4.14) = 5.3467E+007$$

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

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, $V_{r1} = 152467.812$

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

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: $V_c = 68692.008$

= 1 (normal-weight concrete)

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

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

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

$$b_w = 400.00$$

$$d = 240.00$$

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

$$M_u = 1.0885753E-012$$

$$V_u = 4.9175078E-016$$

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)

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

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

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

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

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

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: $V_c = 68692.008$

= 1 (normal-weight concrete)

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

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

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

$$b_w = 400.00$$

$$d = 240.00$$

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

$$M_u = 1.7913670E-013$$

$$V_u = 4.9175078E-016$$

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)

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

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

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

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: 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: $A_{st} = 615.7522$
-Compression: $A_{sc} = 911.0619$
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 $\phi_{u,R} = \phi_u = 0.00602588$
 $\phi_u = \phi_y + \phi_p = 0.00708927$

- Calculation of ϕ_y -

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

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

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

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

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

$$d = 258.00$$

$$y = 0.28791623$$

$$A = 0.01481442$$

$$B = 0.00862128$$

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

$$p_c = 0.00493157$$

$$p_v = 0.00493157$$

$$N = 506.3875$$

$$b = 400.00$$

$$" = 0.1627907$$

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

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

$$E_c = 21019.039$$

$$y = 0.28769614$$

$$A = 0.01478038$$

$$B = 0.00860158$$

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

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)

$$= -5.0000144\text{E-}022$$

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

$$- (- ')/ \text{bal} = -0.15320811$$

$$= A_{st}/(b_w \cdot d) = 0.00596659$$

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

$$' = A_{sc}/(b_w \cdot d) = 0.00882812$$

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

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

$$f_c = 20.00$$

$$f_y = 444.4444$$

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

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

$$\phi_y = 0.00222222$$

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

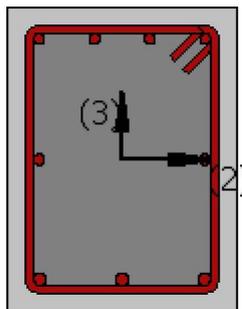
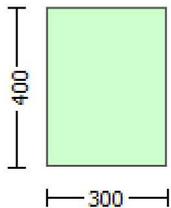
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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 $l_o/l_{ou,min} = l_b/l_d = 0.30$
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: $As_t = 603.1858$

-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 $V_R = *V_n = 116312.49$
 $V_n ((22.5.1.1), ACI 318-14) = 136838.224$

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)

$\rho_w = As/(b_w*d) = 0.00628319$

As (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

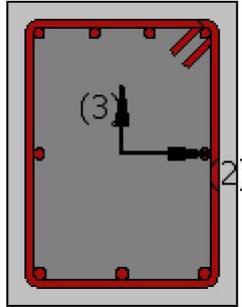
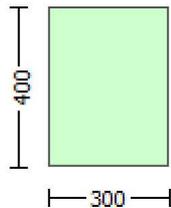
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 2740.264$

EDGE -B-

Shear Force, $V_b = 2740.264$
BOTH EDGES
Axial Force, $F = -224.0408$
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: $As_{c,mid} = 307.8761$

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 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 the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 2740.264$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = 2740.264$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature 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_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
 $b_o = 240.00$
 $h_o = 340.00$
 $bi_2 = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

 $p_{sh,x}$ (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 stirrups, ns = 2.00
bk = 400.00

s = 150.00
fywe = 555.5556
fce = 20.00

From ((5.A.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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

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

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, TBDY) = 21.84352

cc (5A.5, TBDY) = 0.00292176

c = confinement factor = 1.09218

1 = $Asl,ten/(b*d)*(fs1/fc) = 0.11959521$

2 = $Asl,com/(b*d)*(fs2/fc) = 0.12208678$

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) = 0.19872953

Mu = MRc (4.14) = 8.0426E+007

u = su (4.1) = 1.7898746E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/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

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/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) = 0.08921201

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 = 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 lb/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:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

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

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

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

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

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

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

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

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

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

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

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

$$b_k = 300.00$$

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

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

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

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

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

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

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

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

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

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

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

$$y_v = 0.0012967$$

$$sh_v = 0.0044814$$

$$ft_v = 373.4504$$

$$fy_v = 311.2087$$

$$s_{uv} = 0.00512$$

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

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

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

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

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = f_s = 311.2087$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.08739136$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.08921201$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04460601$$

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 21.84352$$

$$cc (5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.11923059$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.12171456$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06085728$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.19929283$$

$$\mu_u = M_{Rc} (4.14) = 8.0508E+007$$

$$u = s_u (4.1) = 1.7861306E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7938121E-005$$

$$\mu_u = 8.1848E+007$$

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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
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 = $\text{Astir} * ns = 78.53982$
No stirups, ns = 2.00
bk = 300.00

psh,y (5.4d) = 0.00261799
Ash = $\text{Astir} * ns = 78.53982$
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
 $lo/lou,min = lb/d = 0.30$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu1_nominal = 0.08$,
For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191

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

su (4.9) = 0.20048836

Mu = MRc (4.14) = 8.1848E+007

u = su (4.1) = 1.7938121E-005

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 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) '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: $V_c = 78946.167$
= 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

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.3467E+007$

$M_{u1+} = 5.3467E+007$, 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

$M_{u1-} = 5.3467E+007$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.3467E+007$

$M_{u2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.3467E+007$, 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

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

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 M_{u1+}

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:

$b = 400.00$

$d = 258.00$

$d' = 42.00$

$v = 0.00010855$

$N = 224.0408$

$f_c = 20.00$

ω (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

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00261799$

$\phi_{sh,x}$ (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, ns = 2.00
bk = 300.00

psh,y (5.4d) = 0.00261799
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 400.00

s = 150.00
fywe = 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/d = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = fs = 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 = 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 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* = 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

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 311.2087$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 311.2087$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 311.2087$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736$$

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

--->

$$su (4.9) = 0.21754625$$

$$Mu = MRc (4.14) = 5.3467E+007$$

$$u = s_u(4.1) = 2.5362472E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 2.5362472E-005$$

$$\mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o(5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu_c = 0.00777035$$

$$\mu_{cc} \text{ (5.4c)} = 0.01139744$$

$$a_{se} \text{ ((5.4d), TB DY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

$$\mu_{sh, \min} = \text{Min}(\mu_{sh, x}, \mu_{sh, y}) = 0.00261799$$

$$\mu_{sh, x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$\mu_{sh, y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$s_{u1} = 0.00512$$

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

$$l_o/l_{o, \min} = l_b/d = 0.30$$

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TB DY)} = 0.032$$

$$\text{From table 5A.1, TB DY: } s_{u1_nominal} = 0.08,$$

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.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 311.2087$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0012967$$

$sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
 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
 $lo/lo_{min} = lb/lb_{min} = 0.30$
 $su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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.
 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:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.1021581$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.1021581$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - 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 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

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 = $\text{Astir} * ns = 78.53982$

No stirups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = $\text{Astir} * ns = 78.53982$

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 = $lb/d = 0.30$

su1 = $0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = fs = 311.2087$

with $Es2 = Es = 200000.00$

$y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $su_v = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{min} = lb/d = 0.30$
 $su_v = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fs_v = fsv/1.2$, 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 $Min(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 311.2087$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.07673736$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.07673736$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.07673736$

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/d

Inadequate Lap Length with $lb/d = 0.30$

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) '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)
 $fc' = 20.00$, but $fc'^{0.5} <= 8.3$ MPa (22.5.3.1, ACI 318-14)
 $pw = As/(bw*d) = 0.00628319$
 As (tension reinf.) = 603.1858
 $bw = 400.00$
 $d = 240.00$
 $Vu*d/Mu < 1 = 0.00$
 $Mu = 1.0885753E-012$
 $Vu = 4.9175078E-016$
 From (11.5.4.8), ACI 318-14: $V_s = 83775.804$
 $Av = 157079.633$

$$f_y = 444.4444$$

$$s = 150.00$$

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) '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)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w * d) = 0.00628319$$

$$A_s (\text{tension reinf.}) = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u * d / M_u < 1 = 0.00$$

$$M_u = 1.7913670E-013$$

$$V_u = 4.9175078E-016$$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

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, $M = 5.3886E+006$
Shear Force, $V2 = -1.0034397E-014$
Shear Force, $V3 = -3205.931$
Axial Force, $F = -577.3164$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 603.1858$
-Compression: $As_c = 923.6282$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{,ten} = 603.1858$
-Compression: $As_{,com} = 615.7522$
-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 $u_{,R} = u = 0.02813934$
 $u = y + p = 0.0331051$

- 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, $\lambda < 2$ (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

- ($\lambda - 1$)/ $\lambda = -0.16019328$

$= A_{s1}/(b_w \cdot d) = 0.00563199$

Tension Reinf Area: $A_{s1} = 603.1858$

$\lambda = A_{s2}/(b_w \cdot d) = 0.00862398$

Compression Reinf Area: $A_{s2} = 923.6282$

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): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \lambda) = 0.57446809$

$\lambda = 0.00222222$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 0.08060704$, 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

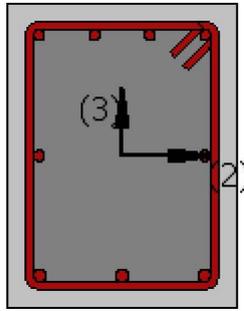
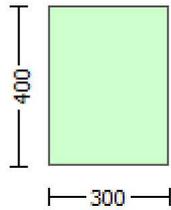
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.85$

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, $M_a = 5.3886E+006$

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: $A_{st} = 603.1858$

-Compression: $A_{sc} = 923.6282$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 603.1858$

-Compression: $A_{st,com} = 615.7522$

-Middle: $A_{st,mid} = 307.8761$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 16.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = *V_n = 167818.491$

$V_n ((22.5.1.1), ACI 318-14) = 197433.519$

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
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\mu < 1 = 0.19038443$
 $\mu = 5.3886E+006$
 $V_u = 3205.931$

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

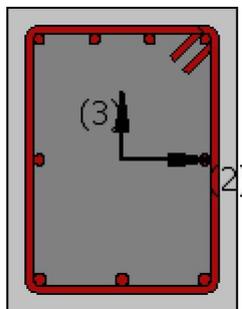
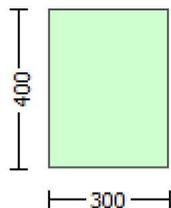
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.85$

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 $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 2740.264$

EDGE -B-

Shear Force, $V_b = 2740.264$

BOTH EDGES

Axial Force, $F = -224.0408$

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

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.1931E+007$

$M_{u1+} = 8.0426E+007$, 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

$M_{u1-} = 8.1931E+007$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.1848E+007$

$M_{u2+} = 8.0508E+007$, 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

$M_{u2-} = 8.1848E+007$, 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:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e \text{ (5.4c)} = 0.01139744$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

 $p_{sh,x} \text{ (5.4d)} = 0.00349066$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

 $p_{sh,y} \text{ (5.4d)} = 0.00261799$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 311.2087$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = fs = 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*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, TBDY) = 21.84352

cc (5A.5, TBDY) = 0.00292176

c = confinement factor = 1.09218

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11959521

2 = Asl,com/(b*d)*(fs2/fc) = 0.12208678

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) = 0.19872953

Mu = MRc (4.14) = 8.0426E+007

u = su (4.1) = 1.7898746E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 1.7900352E-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 ((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/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

$l_o/l_{o,min} = l_b/d = 0.30$

$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,

considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and γ_v , sh_v, ft_v, f_{y_v} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1, ft_1, f_{y_1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 311.2087$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.08921201$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.08739136$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04460601$

and confined core properties:

$b = 240.00$

$d = 328.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 21.84352$

$cc (5A.5, TBDY) = 0.00292176$

$c =$ confinement factor $= 1.09218$

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.12171456$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.11923059$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06085728$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$s_u (4.9) = 0.20103941$

$M_u = MR_c (4.14) = 8.1931E+007$

$u = s_u (4.1) = 1.7900352E-005$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 1.7861306E-005$

$M_u = 8.0508E+007$

with full section properties:

$b = 300.00$

$d = 358.00$

$d' = 43.00$

$v = 0.0001043$

$N = 224.0408$

$f_c = 20.00$

$co (5A.5, TBDY) = 0.002$

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: $cu = 0.00777035$

$w_e (5.4c) = 0.01139744$

$ase ((5.4d), TBDY) = 0.15672608$

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

$psh,min = \text{Min}(psh,x, psh,y) = 0.00261799$

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.A.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) = 0.08739136

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

--->

$$s_u (4.9) = 0.19929283$$

$$M_u = MR_c (4.14) = 8.0508E+007$$

$$u = s_u (4.1) = 1.7861306E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7938121E-005$$

$$M_u = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e (5.4c) = 0.01139744$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} (5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191

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

---->

su (4.9) = 0.20048836
Mu = MRc (4.14) = 8.1848E+007
u = su (4.1) = 1.7938121E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 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} <= 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: Vs + Vf <= 285202.276

Calculation of Shear Strength at edge 2, Vr2 = 227880.93
Vr2 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: Vc = 78946.167
= 1 (normal-weight concrete)
fc' = 20.00, but fc^{0.5} <= 8.3 MPa (22.5.3.1, ACI 318-14)
pw = As/(bw*d) = 0.00628319
As (tension reinf.) = 603.1858
bw = 300.00
d = 320.00
Vu*d/Mu < 1 = 1.00
Mu = 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: Vs + Vf <= 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 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u * l_n / 2 = 57801.946$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.3467E+007$

$M_{u1+} = 5.3467E+007$, 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

$M_{u1-} = 5.3467E+007$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.3467E+007$

$M_{u2+} = 5.3467E+007$, 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

$M_{u2-} = 5.3467E+007$, 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:

$$u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$fc = 20.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00777035$$

$$\phi_{ue} \text{ (5.4c)} = 0.01139744$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00261799$$

 $\phi_{psh,x} \text{ (5.4d)} = 0.00349066$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

 $\phi_{psh,y} \text{ (5.4d)} = 0.00261799$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 311.2087$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 311.2087$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 311.2087$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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 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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e (5.4c) = 0.01139744$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

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, $n_s = 2.00$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and y_1, sh_1, 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, 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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and y_2, sh_2, 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, 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/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 $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07673736$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 21.84352$$

$$c_c (5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.21754625$$

$$M_u = M_{Rc} (4.14) = 5.3467E+007$$

$$u = s_u (4.1) = 2.5362472E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e (5.4c) = 0.01139744$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir}*n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} (5.4d) = 0.00261799$$

$$A_{sh} = A_{stir}*n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

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.

$$\text{with } fs1 = fs = 311.2087$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 311.2087$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 311.2087$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.21754625$$

$$M_u = MR_c(4.14) = 5.3467E+007$$

$$u = s_u(4.1) = 2.5362472E-005$$

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, $V_{r1} = 152467.812$

$$V_{r1} = V_n((22.5.1.1), \text{ACI 318-14})$$

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 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s/(b_w*d) = 0.00628319$$

$$A_s \text{ (tension reinf.)} = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u*d/M_u < 1 = 0.00$$

$$M_u = 1.0885753E-012$$

$$V_u = 4.9175078E-016$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 83775.804$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

V_s has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

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 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s/(b_w*d) = 0.00628319$$

$$A_s \text{ (tension reinf.)} = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u*d/M_u < 1 = 0.00$$

$$M_u = 1.7913670E-013$$

$$V_u = 4.9175078E-016$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 83775.804$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

V_s has been multiplied by 2(1-s/d) (s>d/2, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.75$$

$$V_f((11-3)-(11.4), \text{ACI 440}) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

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: 3
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, $M = 3.2956043E-012$
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 $u_{,R} = \gamma \cdot u = 0.02727624$
 $u = \gamma \cdot u + p = 0.03208969$

- Calculation of γ -

$\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.00208969$ ((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 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 6.7762196\text{E-}006$$

$$\text{with } ((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 248.9669$$

$$d = 258.00$$

$$y = 0.28795984$$

$$A = 0.01481718$$

$$B = 0.00862404$$

$$\text{with } p_t = 0.00493157$$

$$p_c = 0.00493157$$

$$p_v = 0.00493157$$

$$N = 577.3164$$

$$b = 400.00$$

$$" = 0.1627907$$

$$y_{\text{comp}} = 2.3073663\text{E-}005$$

$$\text{with } f_c = 20.00$$

$$E_c = 21019.039$$

$$y = 0.28770896$$

$$A = 0.01477838$$

$$B = 0.00860158$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of ϕ_p -

From table 10-7: $\phi_p = 0.03$

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)

$$= 2.6052417\text{E-}021$$

- 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 = $1.0034397\text{E-}014$

- (ϕ_p) / $\phi_{\text{bal}} = -0.1662471$

$$= A_{s1}/(b_w \cdot d) = 0.00584482$$

Tension Reinf Area: $A_{s1} = 603.1858$

$$\phi_p = A_{s1}/(b_w \cdot d) = 0.00894989$$

Compression Reinf Area: $A_{s1} = 923.6282$

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): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \phi_y) = 0.57446809$

$$\phi_y = 0.00222222$$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 2.6183026\text{E-}019$, 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

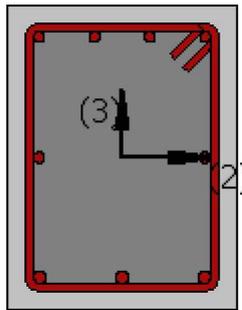
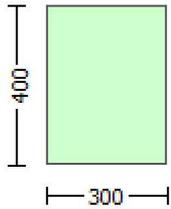
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: beam B1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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 $l_o/l_{o,min} = l_b/d = 0.30$
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: $A_{st} = 615.7522$

-Compression: $A_{sc} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{s,ten} = 508.938$

-Compression: $A_{s,com} = 508.938$

-Middle: $A_{s,mid} = 508.938$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 14.66667$

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_vV_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)

$\rho_w = A_s/(b_w \cdot d) = 0.00641409$

A_s (tension reinf.) = 615.7522

$b_w = 400.00$

$d = 240.00$

$V_u \cdot d / M_u < 1 = 0.00$

$M_u = 2.1868695E-011$

$V_u = 1.0034397E-014$

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

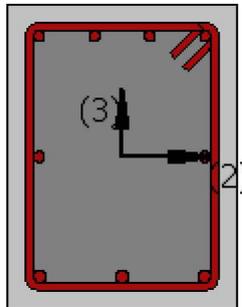
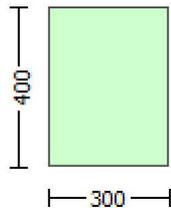
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

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, $f_s = 1.25 \cdot f_{sm} = 555.5556$

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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 $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 2740.264$

EDGE -B-

Shear Force, $V_b = 2740.264$
BOTH EDGES
Axial Force, $F = -224.0408$
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: $As_{,ten} = 603.1858$
-Compression: $As_{,com} = 615.7522$
-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
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.1931E+007$
 $Mu_{1+} = 8.0426E+007$, 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 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 the static loading combination
and
 $\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$
with
 $V_1 = 2740.264$, is the shear force acting at edge 1 for the the static loading combination
 $V_2 = 2740.264$, is the shear force acting at edge 2 for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature 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_c (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00777035$
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
 $b_o = 240.00$
 $h_o = 340.00$
 $bi_2 = 346400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

 $p_{sh,x}$ (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 stirups, ns = 2.00
bk = 400.00

s = 150.00
fywe = 555.5556
fce = 20.00

From ((5.A.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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = fs = 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*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, TBDY) = 21.84352

cc (5A.5, TBDY) = 0.00292176

c = confinement factor = 1.09218

1 = $Asl,ten/(b*d)*(fs1/fc) = 0.11959521$

2 = $Asl,com/(b*d)*(fs2/fc) = 0.12208678$

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) = 0.19872953

Mu = MRc (4.14) = 8.0426E+007

u = su (4.1) = 1.7898746E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/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

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/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) = 0.08921201

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 = 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 lb/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:

$$b = 300.00$$

$$d = 358.00$$

$$d' = 43.00$$

$$v = 0.0001043$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e \text{ (5.4c)} = 0.01139744$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 311.2087$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,

For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = f_s = 311.2087$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0012967$$

$$sh_v = 0.0044814$$

$$ft_v = 373.4504$$

$$fy_v = 311.2087$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = f_s = 311.2087$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.08739136$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.08921201$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04460601$$

and confined core properties:

$$b = 240.00$$

$$d = 328.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 21.84352$$

$$cc (5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.11923059$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.12171456$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06085728$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.19929283$$

$$\mu_u = MR_c (4.14) = 8.0508E+007$$

$$u = s_u (4.1) = 1.7861306E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7938121E-005$$

$$\mu_u = 8.1848E+007$$

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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
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 = $\text{Astir} * ns = 78.53982$
No stirups, ns = 2.00
bk = 300.00

psh,y (5.4d) = 0.00261799
Ash = $\text{Astir} * ns = 78.53982$
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
 $lo/lou,min = lb/d = 0.30$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu1_nominal = 0.08$,
For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191

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

su (4.9) = 0.20048836

Mu = MRc (4.14) = 8.1848E+007

u = su (4.1) = 1.7938121E-005

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 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) '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: $V_c = 78946.167$
= 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

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.3467E+007$

$M_{u1+} = 5.3467E+007$, 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

$M_{u1-} = 5.3467E+007$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.3467E+007$

$M_{u2+} = 5.3467E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.3467E+007$, 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

$\pm w_u \cdot l_n = (|V_1| + |V_2|)/2$

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 M_{u1+}

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_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_c, \phi_{cc}) = 0.00777035$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_{cu} = 0.00777035$

w_e (5.4c) = 0.01139744

a_{se} ((5.4d), TBDY) = 0.15672608

$b_o = 240.00$

$h_o = 340.00$

$b_{i2} = 346400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00261799$

$\phi_{sh,x}$ (5.4d) = 0.00349066

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, ns = 2.00
bk = 300.00

psh,y (5.4d) = 0.00261799
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 400.00

s = 150.00
fywe = 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/d = 0.30

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = fs = 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 = $Asl,mid/(b*d)*(fsv/fc)$ = 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/l_d

Inadequate Lap Length with lb/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
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

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 311.2087$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 311.2087$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 311.2087$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07673736$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.07673736$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07673736$$

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

--->

$$su (4.9) = 0.21754625$$

$$Mu = MRc (4.14) = 5.3467E+007$$

$$u = s_u(4.1) = 2.5362472E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 2.5362472E-005$$

$$\mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o(5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu_c = 0.00777035$$

$$\mu_{cc} \text{ (5.4c)} = 0.01139744$$

$$a_{se} \text{ ((5.4d), TB DY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_i^2 = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} \text{ (5.4d)} = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_{cc} = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$s_{u1} = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TB DY)} = 0.032$$

$$\text{From table 5A.1, TB DY: } s_{u1_nominal} = 0.08,$$

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.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 311.2087$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0012967$$

$sh_2 = 0.0044814$
 $ft_2 = 373.4504$
 $fy_2 = 311.2087$
 $su_2 = 0.00512$
 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
 $lo/lo_{min} = lb/lb_{min} = 0.30$
 $su_2 = 0.4 * esu_{2_nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 311.2087$
 with $Es_2 = Es = 200000.00$
 $yv = 0.0012967$
 $shv = 0.0044814$
 $ftv = 373.4504$
 $fyv = 311.2087$
 $suv = 0.00512$
 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.
 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:
 $b = 340.00$
 $d = 228.00$
 $d' = 12.00$
 $f_{cc} (5A.2, TBDY) = 21.84352$
 $cc (5A.5, TBDY) = 0.00292176$
 $c = \text{confinement factor} = 1.09218$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.1021581$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.1021581$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.1021581$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - 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 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

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 = $\text{Astir} * ns = 78.53982$

No stirups, ns = 2.00

bk = 300.00

psh,y (5.4d) = 0.00261799

Ash = $\text{Astir} * ns = 78.53982$

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 = $lb/d = 0.30$

su1 = $0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = fs = 311.2087$

with $Es2 = Es = 200000.00$

$y_v = 0.0012967$
 $sh_v = 0.0044814$
 $ft_v = 373.4504$
 $fy_v = 311.2087$
 $su_v = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{min} = lb/ld = 0.30$
 $su_v = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_v = fsv/1.2$, 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) '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)
 $fc' = 20.00$, but $fc'^{0.5} <= 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $pw = As/(bw*d) = 0.00628319$
 As (tension reinf.) = 603.1858
 $bw = 400.00$
 $d = 240.00$
 $Vu*d/Mu < 1 = 0.00$
 $Mu = 1.0885753E-012$
 $Vu = 4.9175078E-016$
 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) '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)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w * d) = 0.00628319$$

$$A_s (\text{tension reinf.}) = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u * d / \mu_u < 1 = 0.00$$

$$\mu_u = 1.7913670E-013$$

$$V_u = 4.9175078E-016$$

From (11.5.4.8), ACI 318-14: $V_s = 83775.804$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

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

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, $M = 5.6119E+006$
Shear Force, $V2 = 1.0034397E-014$
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: $As_{,ten} = 615.7522$
-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 $u_{,R} = \rho \cdot u = 0.02653457$
 $u = \rho + p = 0.03121714$

- Calculation of ρ -

$\rho = (M_y \cdot L_s / 3) / E_{eff} = 0.00121714$ ((4.29), Biskinis Phd))
 $M_y = 5.7023E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 646.0505
From table 10.5, ASCE 41_17: $E_{eff} = 0.3 \cdot E_c \cdot I_g = 1.0089E+013$

Calculation of Yielding Moment M_y

Calculation of ρ and M_y according to Annex 7 -

$\rho = \text{Min}(\rho_{,ten}, \rho_{,com})$
 $\rho_{,ten} = 4.8184688E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b / d)^{2/3}) = 248.9669$
 $d = 358.00$
 $\rho = 0.27836167$
 $A = 0.01423774$
 $B = 0.0080349$
with $p_t = 0.00573326$
 $p_c = 0.00561626$
 $p_v = 0.00286663$
 $N = 577.3164$
 $b = 300.00$
 $\rho = 0.12011173$
 $\rho_{,comp} = 1.7202837E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $\rho = 0.27810356$
 $A = 0.01420045$
 $B = 0.00801331$
with $E_s = 200000.00$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

- Calculation of p -

From table 10-7: $p = 0.03$
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, $\lambda < 2$ (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

- ($\lambda - 1$)/ $\lambda = -0.14721673$

$= A_{st}/(b_w \cdot d) = 0.00573326$

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): $87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \lambda) = 0.57446809$

$\lambda = 0.00222222$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 0.21779444$, 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

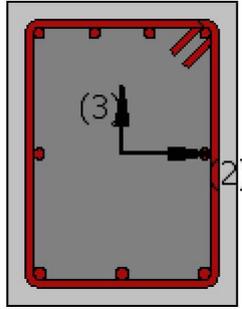
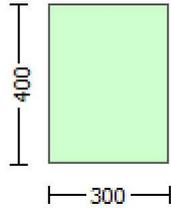
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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, $\gamma = 0.85$

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, $M_a = 5.3886E+006$

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: $A_{sl,ten} = 615.7522$

-Compression: $A_{sl,com} = 911.0619$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 615.7522$

-Compression: $A_{sl,com} = 603.1858$

-Middle: $A_{sl,mid} = 307.8761$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 14.00$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = *V_n = 170566.239$

$V_n ((22.5.1.1), ACI 318-14) = 200666.163$

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
 $b_w = 300.00$
 $d = 320.00$
 $V_u*d/\mu < 1 = 0.49531735$
 $\mu = 5.6119E+006$
 $V_u = 8686.46$
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

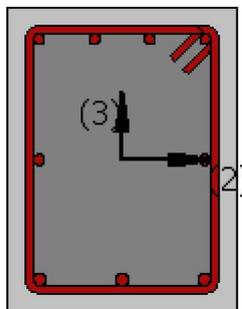
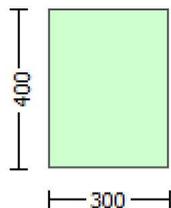
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: beam B1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)

Section Type: rcars

Constant Properties

Knowledge Factor, $\gamma = 0.85$

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 $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 2740.264$

EDGE -B-

Shear Force, $V_b = 2740.264$

BOTH EDGES

Axial Force, $F = -224.0408$

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

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 8.1931E+007$

$M_{u1+} = 8.0426E+007$, 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

$M_{u1-} = 8.1931E+007$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 8.1848E+007$

$M_{u2+} = 8.0508E+007$, 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

$M_{u2-} = 8.1848E+007$, 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:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e \text{ (5.4c)} = 0.01139744$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

 $p_{sh,x} \text{ (5.4d)} = 0.00349066$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

 $p_{sh,y} \text{ (5.4d)} = 0.00261799$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 311.2087$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4504$$

$$fy_2 = 311.2087$$

$$su_2 = 0.00512$$

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

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = fs = 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*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, TBDY) = 21.84352

cc (5A.5, TBDY) = 0.00292176

c = confinement factor = 1.09218

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11959521

2 = Asl,com/(b*d)*(fs2/fc) = 0.12208678

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) = 0.19872953

Mu = MRc (4.14) = 8.0426E+007

u = su (4.1) = 1.7898746E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 1.7900352E-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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00777035$
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 = 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/d = 0.30
su1 = $0.4 * \text{esu1_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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 = $0.4 * \text{esu2_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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

$l_o/l_{o,min} = l_b/l_d = 0.30$

$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and γ_v , sh_v, ft_v, fy_v , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 311.2087$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.08921201$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.08739136$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04460601$

and confined core properties:

$b = 240.00$

$d = 328.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 21.84352$

$cc (5A.5, TBDY) = 0.00292176$

$c = \text{confinement factor} = 1.09218$

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.12171456$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.11923059$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06085728$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$s_u (4.9) = 0.20103941$

$M_u = M_{Rc} (4.14) = 8.1931E+007$

$u = s_u (4.1) = 1.7900352E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 1.7861306E-005$

$M_u = 8.0508E+007$

with full section properties:

$b = 300.00$

$d = 358.00$

$d' = 43.00$

$v = 0.0001043$

$N = 224.0408$

$f_c = 20.00$

$co (5A.5, TBDY) = 0.002$

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: $cu = 0.00777035$

$w_e (5.4c) = 0.01139744$

$ase ((5.4d), TBDY) = 0.15672608$

$bo = 240.00$

$ho = 340.00$

$bi_2 = 346400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$

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.A.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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = fs = 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*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

--->

$$s_u (4.9) = 0.19929283$$

$$M_u = MR_c (4.14) = 8.0508E+007$$

$$u = s_u (4.1) = 1.7861306E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.7938121E-005$$

$$M_u = 8.1848E+007$$

with full section properties:

$$b = 300.00$$

$$d = 357.00$$

$$d' = 42.00$$

$$v = 0.00010459$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e (5.4c) = 0.01139744$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} (5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = fs = 311.2087

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.08946191

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

---->

su (4.9) = 0.20048836
Mu = MRc (4.14) = 8.1848E+007
u = su (4.1) = 1.7938121E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 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 <= 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: Vs + Vf <= 285202.276

Calculation of Shear Strength at edge 2, Vr2 = 227880.93
Vr2 = Vn ((22.5.1.1), ACI 318-14)

NOTE: In expression (22.5.1.1) 'Vw' is replaced by 'Vw+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

From Table (22.5.5.1), ACI 318-14: Vc = 78946.167
= 1 (normal-weight concrete)
fc' = 20.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
pw = As/(bw*d) = 0.00628319
As (tension reinf.) = 603.1858
bw = 300.00
d = 320.00
Vu*d/Mu < 1 = 1.00
Mu = 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: Vs + Vf <= 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: $A_{st} = 603.1858$
-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 $V_e = (M_{pr1} + M_{pr2})/l_n \pm w_u * l_n / 2 = 57801.946$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.3467E+007$
 $M_{u1+} = 5.3467E+007$, 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
 $M_{u1-} = 5.3467E+007$, 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
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.3467E+007$
 $M_{u2+} = 5.3467E+007$, 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
 $M_{u2-} = 5.3467E+007$, 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:

$$u = 2.5362472E-005$$

$$Mu = 5.3467E+007$$

with full section properties:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$fc = 20.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00777035$$

$$\phi_{ue} \text{ (5.4c)} = 0.01139744$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00261799$$

 $\phi_{sh,x} \text{ (5.4d)} = 0.00349066$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

 $\phi_{sh,y} \text{ (5.4d)} = 0.00261799$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

 $s = 150.00$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * \text{esu1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } \text{esu1_nominal} = 0.08,$$

For calculation of esu1_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.

$$\text{with } fs_1 = fs = 311.2087$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0012967$$

$$sh_2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 311.2087$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 311.2087$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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 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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_o (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e (5.4c) = 0.01139744$$

$$a_{se} ((5.4d), \text{TBDY}) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

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, $n_s = 2.00$

$$b_k = 400.00$$

$$s = 150.00$$

$$f_{ywe} = 555.5556$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$y_1 = 0.0012967$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4504$$

$$fy_1 = 311.2087$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and y_1, sh_1, 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, 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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and y_2, sh_2, 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, 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/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 $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07673736$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07673736$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07673736$$

and confined core properties:

$$b = 340.00$$

$$d = 228.00$$

$$d' = 12.00$$

$$f_{cc} (5A.2, TBDY) = 21.84352$$

$$c_c (5A.5, TBDY) = 0.00292176$$

$$c = \text{confinement factor} = 1.09218$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1021581$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1021581$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.1021581$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.21754625$$

$$M_u = M_{Rc} (4.14) = 5.3467E+007$$

$$u = s_u (4.1) = 2.5362472E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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:

$$b = 400.00$$

$$d = 258.00$$

$$d' = 42.00$$

$$v = 0.00010855$$

$$N = 224.0408$$

$$f_c = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00777035$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00777035$$

$$w_e (5.4c) = 0.01139744$$

$$a_{se} ((5.4d), TBDY) = 0.15672608$$

$$b_o = 240.00$$

$$h_o = 340.00$$

$$b_{i2} = 346400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00261799$$

$$p_{sh,x} (5.4d) = 0.00349066$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 300.00$$

$$p_{sh,y} (5.4d) = 0.00261799$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 400.00$$

$$s = 150.00$$

$$fywe = 555.5556$$

$$fce = 20.00$$

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

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = fs = 311.2087$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0012967$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4504$$

$$fy2 = 311.2087$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 311.2087$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0012967$$

$$shv = 0.0044814$$

$$ftv = 373.4504$$

$$fyv = 311.2087$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 311.2087$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07673736$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07673736$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07673736$$

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: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.21754625$$

$$M_u = MR_c(4.14) = 5.3467E+007$$

$$u = s_u(4.1) = 2.5362472E-005$$

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, $V_{r1} = 152467.812$

$$V_{r1} = V_n \text{ ((22.5.1.1), ACI 318-14)}$$

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).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 68692.008$$

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w \cdot d) = 0.00628319$$

$$A_s \text{ (tension reinf.)} = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u \cdot d / M_u < 1 = 0.00$$

$$M_u = 1.0885753E-012$$

$$V_u = 4.9175078E-016$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 83775.804$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

V_s has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.75$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

Calculation of Shear Strength at edge 2, $V_{r2} = 152467.812$

$$V_{r2} = V_n \text{ ((22.5.1.1), ACI 318-14)}$$

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).

$$\text{From Table (22.5.5.1), ACI 318-14: } V_c = 68692.008$$

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$p_w = A_s / (b_w \cdot d) = 0.00628319$$

$$A_s \text{ (tension reinf.)} = 603.1858$$

$$b_w = 400.00$$

$$d = 240.00$$

$$V_u \cdot d / M_u < 1 = 0.00$$

$$M_u = 1.7913670E-013$$

$$V_u = 4.9175078E-016$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 83775.804$$

$$A_v = 157079.633$$

$$f_y = 444.4444$$

$$s = 150.00$$

V_s has been multiplied by $2(1-s/d)$ ($s > d/2$, according to ASCE 41-17,10.3.4)

$$2(1-s/d) = 0.75$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 285202.276$$

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: 3
Integration Section: (b)
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, $M = -2.1868695E-011$
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: $A_{st} = 615.7522$
-Compression: $A_{sc} = 911.0619$
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 $u_{,R} = \gamma \cdot u = 0.02727624$
 $u = \gamma \cdot u + p = 0.03208969$

- Calculation of γ -

$\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.00208969$ ((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 ρ_y and M_y according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 6.7762196\text{E-}006$$

$$\text{with } ((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 248.9669$$

$$d = 258.00$$

$$y = 0.28795984$$

$$A = 0.01481718$$

$$B = 0.00862404$$

$$\text{with } p_t = 0.00493157$$

$$p_c = 0.00493157$$

$$p_v = 0.00493157$$

$$N = 577.3164$$

$$b = 400.00$$

$$" = 0.1627907$$

$$y_{\text{comp}} = 2.3073663\text{E-}005$$

$$\text{with } f_c = 20.00$$

$$E_c = 21019.039$$

$$y = 0.28770896$$

$$A = 0.01477838$$

$$B = 0.00860158$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

- Calculation of ρ_p -

From table 10-7: $\rho_p = 0.03$

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, $\rho_y < 2$ (table 10-6, ASCE 41-17)

$$= -6.0732723\text{E-}022$$

- 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 = $1.0034397\text{E-}014$

$$- (- ')/ \text{ bal} = -0.15320811$$

$$= A_{st}/(b_w \cdot d) = 0.00596659$$

$$\text{Tension Reinf Area: } A_{st} = 615.7522$$

$$' = A_{sc}/(b_w \cdot d) = 0.00882812$$

$$\text{Compression Reinf Area: } A_{sc} = 911.0619$$

From (B-1), ACI 318-11: $\text{ bal} = 0.01867739$

$$f_c = 20.00$$

$$f_y = 444.4444$$

$$\text{From 10.2.7.3, ACI 318-11: } \rho_1 = 0.85$$

$$\text{From fig R10.3.3, ACI 318-11 (Ence 454, too): } 87000/(87000 + f_y) = c_b/d_t = 0.003/(0.003 + \rho_y) = 0.57446809$$

$$\rho_y = 0.00222222$$

- $V/(b_w \cdot d \cdot f_c^{0.5}) = 2.6183026\text{E-}019$, 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)
