

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

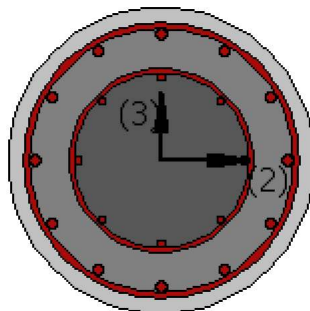
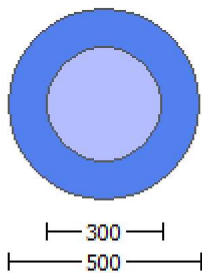
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

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Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
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Note: Especially for the calculation of  $\mu_y$  for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
#####
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping
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Stepwise Properties
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EDGE -A-
Bending Moment, Ma = -1.4067E+007
Shear Force, Va = -4687.847
EDGE -B-
Bending Moment, Mb = 0.05009779
Shear Force, Vb = 4687.847
BOTH EDGES
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension: Aslt = 0.00
  -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension: Asl,ten = 1017.876
  -Compression: Asl,com = 1017.876
  -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00
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New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 334974.714
Vn ((10.3), ASCE 41-17) = knl*VColO = 334974.714
VCol = 334974.714
knl = 1.00
displacement_ductility_demand = 0.02522788
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NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
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= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.4067E+007

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$V_u = 4687.847$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7387.338$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$
 $V_{s1} = 246740.11$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 373328.906$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

displacement_ductility_demand is calculated as $\frac{\delta}{y}$

- Calculation of $\frac{\delta}{y}$ for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation $\theta = 0.00016354$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00648247$ ((4.29), Biskinis Phd))
 $M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.769
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.3694E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7387.338$
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of δ and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y,ten}, M_{y,com}) = 1.5355E+008$
 $y = 4.4159581E-006$
 $M_{y,ten} (8c) = 1.5355E+008$
 $\delta_{ten} (7c) = 64.86209$
 error of function (7c) = 0.00290243
 $M_{y,com} (8d) = 7.1091E+008$
 $\delta_{com} (7d) = 65.27569$
 error of function (7d) = -0.00596423
 with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 \cdot e_y \cdot (I_b/I_d)^{2/3}) = 0.003125$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125411$
 $N = 7387.338$
 $A_c = 196349.541$
 ((10.1), ASCE 41-17) $\phi = \min(\phi, 1.25 \cdot \phi \cdot (I_b/I_d)^{2/3}) = 0.324$
 with $f_c = 30.00$

Calculation of ratio I_b/I_d

Lap Length: $l_d/l_{d,min} = 0.16240769$

$l_b = 300.00$

$l_d = 1847.203$

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

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 2

column C1, Floor 1

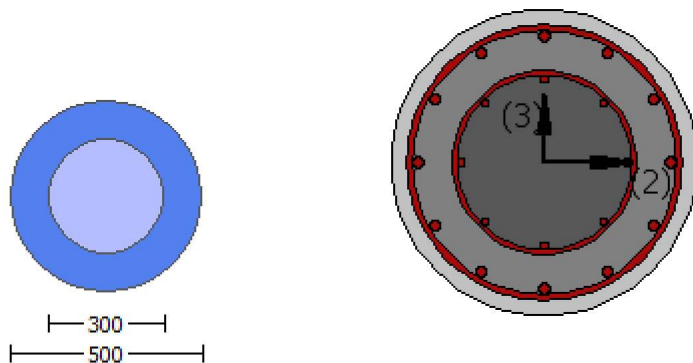
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.36696

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.3940726E-031$

EDGE -B-

Shear Force, $V_b = -3.3940726E-031$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1017.876$

-Compression: $A_{sl,com} = 1017.876$

-Middle: $A_{sl,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$

with

$M_{pr1} = \max(M_{u1+}, M_{u1-}) = 1.6646E+008$

$M_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6646E+008$$

$M_{u2+} = 1.6646E+008$, 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

$M_{u2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 1.6646E+008$

$$= 0.76794487$$

$$\lambda = 0.68333426$$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TB DY: $f_{cc} = f_c \cdot c = 41.00884$

conf. factor $c = 1.36696$

$$f_c = 30.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 250.5135$

$$l_b/d = 0.12992616$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00125393$$

$$N = 7389.214$$

$$A_c = 196349.541$$

$$= \lambda \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$

$$l_b = 300.00$$

$$l_d = 2309.004$$

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

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 4.11234$$

$$A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$$

$$s = s_{external} = 100.00$$

$$n = 12.00$$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 1.6646E+008$

$$= 0.76794487$$

$$\lambda = 0.68333426$$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TB DY: $f_{cc} = f_c \cdot c = 41.00884$

conf. factor $c = 1.36696$

$$f_c = 30.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$\mu = 1.6646E+008$

$= 0.76794487$

$' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$= \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} * \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 250.5135$
 $l_b / d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 0.10389295$

Calculation of ratio l_b / d

Lap Length: $l_b / d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} * \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$
 $V_{r1} = V_{co1}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{co1}$
 $V_{co1} = 524225.731$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 2.0310382E-011$
 $V_u = 3.3940726E-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 78956.835$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 457232.663$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{ColO}}$
 $V_{\text{ColO}} = 524225.731$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 2.0310382E-011$
 $V_u = 3.3940726E-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 78956.835$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 457232.663$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.36696

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.5777218E-030$

EDGE -B-

Shear Force, $V_b = -1.5777218E-030$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$

with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6646\text{E}+008$
 $M_{u1+} = 1.6646\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $M_{u1-} = 1.6646\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6646\text{E}+008$
 $M_{u2+} = 1.6646\text{E}+008$, 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
 $M_{u2-} = 1.6646\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 1.6646\text{E}+008$

$\phi = 0.76794487$
 $\lambda = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TB DY: $f_{cc} = f_c \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 1.6646\text{E}+008$

$\phi = 0.76794487$

$\rho = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$\rho = 0.76794487$
 $\rho = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$Vr1 = VCol \text{ ((10.3), ASCE 41-17)} = knl * VCol0$

$VCol0 = 524225.731$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$\nu_u = 1.5777218E-030$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = /2 * A_stirrup = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = /2 * A_stirrup = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$bw * d = *d * d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $Vr2 = 524225.731$

$Vr2 = VCol \text{ ((10.3), ASCE 41-17)} = knl * VCol0$

$VCol0 = 524225.731$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$\nu_u = 1.5777218E-030$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = /2 * A_stirrup = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = /2 * A_stirrup = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$bw * d = *d * d / 4 = 125663.706$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
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:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
External Diameter, $D = 500.00$
Internal Diameter, $D = 300.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_b = 300.00$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 1.0499072E-009$
Shear Force, $V_2 = -4687.847$
Shear Force, $V_3 = -3.7842421E-013$
Axial Force, $F = -7387.338$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl} = 0.00$
-Compression: $A_{sc} = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1017.876$
-Compression: $A_{sl,com} = 1017.876$
-Middle: $A_{sl,mid} = 1017.876$
Mean Diameter of Tension Reinforcement, $DbL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.0032404$
 $u = \gamma + p = 0.0032404$

- Calculation of γ -

$$\gamma = (M_y * L_s / 3) / E_{eff} = 0.0032404 \text{ ((4.29), Biskinis Phd)}$$

$M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1*L$ and $L_s < 2*L$) = 1500.00
 From table 10.5, ASCE 41-17: $E_{eff} = factor * E_c * I_g = 2.3694E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$
 $N = 7387.338$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y,ten}, M_{y,com}) = 1.5355E+008$
 $\phi_y = 4.4159581E-006$
 $M_{y,ten} (8c) = 1.5355E+008$
 $\phi_{y,ten} (7c) = 64.86209$
 error of function (7c) = 0.00290243
 $M_{y,com} (8d) = 7.1091E+008$
 $\phi_{y,com} (7d) = 65.27569$
 error of function (7d) = -0.00596423
 with ((10.1), ASCE 41-17) $\phi_y = \min(\phi_y, 1.25 * \phi_y * (l_b/l_d)^{2/3}) = 0.003125$
 $\phi_{eco} = 0.002$
 $\phi_{apl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125411$
 $N = 7387.338$
 $A_c = 196349.541$
 ((10.1), ASCE 41-17) $\phi_y = \min(\phi_y, 1.25 * \phi_y * (l_b/l_d)^{2/3}) = 0.324$
 with $f_c = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_d, \min = 0.16240769$
 $l_b = 300.00$
 $l_d = 1847.203$
 Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
 Mean strength value of all re-bars: $f_y = 625.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 * Area_{external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

- Calculation of ϕ_p -

From table 10-9: $\phi_p = 0.00$

with:

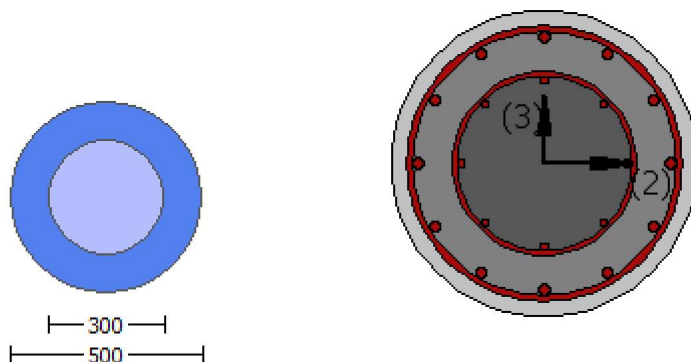
- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$
- shear control ratio $V_y E / V_{col} E = 0.21168476$
- $d = d_{external} = 0.00$
- $s = s_{external} = 0.00$
- $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00323428$

jacket: $s1 = Av1 * (\pi Dc1/2) / (s1 * Ag) = 0.0027646$
 $Av1 = 78.53982$, is the area of stirrup
 $Dc1 = Dext - 2 * cover - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s1 = 100.00$
 core: $s2 = Av2 * (\pi Dc2/2) / (s2 * Ag) = 0.00046968$
 $Av2 = 50.26548$, is the area of stirrup
 $Dc2 = Dint - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s2 = 250.00$
 The term $2 * tf/bw * (ffe/fs)$ is implemented to account for FRP contribution
 where $f = 2 * tf/bw$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength
 All these variables have already been given in Shear control ratio calculation.
 For the normalisation fs of jacket is used.
 $NUD = 7387.338$
 $Ag = 196349.541$
 $f_{cE} = (fc_jacket * Area_jacket + fc_core * Area_core) / section_area = 30.00$
 $f_{yLE} = (fy_ext_Long_Reinf * Area_ext_Long_Reinf + fy_int_Long_Reinf * Area_int_Long_Reinf) / Area_Tot_Long_Rein = 2.1219958E-314$
 $f_{yTE} = (fy_ext_Trans_Reinf * Area_ext_Trans_Reinf + fy_int_Trans_Reinf * Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 625.00$
 $pl = Area_Tot_Long_Rein / (Ag) = 0.015552$
 $f_{cE} = 30.00$

 End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
 At local axis: 2
 Integration Section: (a)

Calculation No. 3

column C1, Floor 1
 Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
 Analysis: Uniform +X
 Check: Shear capacity VRd
 Edge: Start
 Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 1.0499072E-009$

Shear Force, $V_a = -3.7842421E-013$

EDGE -B-

Bending Moment, $M_b = 8.5635974E-011$

Shear Force, $V_b = 3.7842421E-013$

BOTH EDGES

Axial Force, $F = -7387.338$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{l,com} = 1017.876$

-Middle: $As_{l,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 423209.318$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col0} = 423209.318$

$V_{Col} = 423209.318$

$k_n = 1.00$

$\text{displacement_ductility_demand} = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.0499072E-009$

$V_u = 3.7842421E-013$

$d = 0.8 \cdot D = 400.00$

$N_u = 7387.338$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$

$V_{s1} = 246740.11$ is calculated for jacket, with:

$A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$

$f_y = 500.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 78956.835$

$f_y = 500.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 373328.906$

$b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

$\text{displacement_ductility_demand}$ is calculated as $\frac{1}{y}$

- Calculation of $\frac{1}{y}$ for END A -
for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 1.2277408E-020$

$y = (M_y \cdot L_s / 3) / \text{Eleff} = 0.0032404$ ((4.29), Biskinis Phd))

$M_y = 1.5355E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $\text{Eleff} = \text{factor} \cdot E_c \cdot I_g = 2.3694E+013$

$\text{factor} = 0.30$

$A_g = 196349.541$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$

$N = 7387.338$

$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of $\frac{1}{y}$ and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y_{\text{ten}}}, M_{y_{\text{com}}}) = 1.5355E+008$

$y = 4.4159581E-006$

$M_{y_{\text{ten}}} (8c) = 1.5355E+008$

$\frac{1}{y_{\text{ten}}} (7c) = 64.86209$

error of function (7c) = 0.00290243

$M_{y_{\text{com}}} (8d) = 7.1091E+008$

$\rho_{com}(7d) = 65.27569$
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 \cdot e_y \cdot (l_b/l_d)^{2/3}) = 0.003125$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125411$
 $N = 7387.338$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $= \text{Min}(, 1.25 \cdot \cdot (l_b/l_d)^{2/3}) = 0.324$
with $f_c = 30.00$

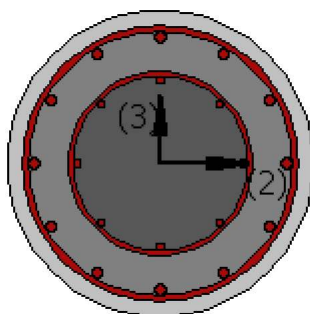
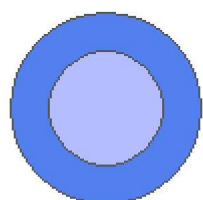
Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.16240769$
 $l_b = 300.00$
 $l_d = 1847.203$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = /2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Chord rotation capacity (ϕ)
Edge: Start
Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.36696

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.3940726E-031$

EDGE -B-

Shear Force, $V_b = -3.3940726E-031$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00
 -Compression: Aslc = 3053.628
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1017.876
 -Compression: Asl,com = 1017.876
 -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , $V_e/V_r = 0.21168476$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$
 with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.6646E+008$
 $Mu_{1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.6646E+008$
 $Mu_{2+} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
 $Mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$

s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.10389295

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00

$R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.10389295$

Calculation of ratio lb/d

Lap Length: $lb/d = 0.12992616$

$lb = 300.00$

$ld = 2309.004$

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

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = /2 * \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 1.6646E+008$

$= 0.76794487$

$' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $fcc = fc' \quad c = 41.00884$

conf. factor $c = 1.36696$

$fc = 30.00$

From 10.3.5, ASCE 41-17, Final value of fy : $fy * Min(1, 1.25 * (lb/d)^{2/3}) = 250.5135$

$lb/d = 0.12992616$

$d1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$Ac = 196349.541$

$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.10389295$

Calculation of ratio lb/d

Lap Length: $lb/d = 0.12992616$

$lb = 300.00$

$ld = 2309.004$

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

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$
 $cb = 25.00$
 $Ktr = 4.11234$
 $A_{tr} = \frac{1}{2} \times \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \times V_{\text{Col}0}$

$V_{\text{Col}0} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \times f_y \times d / s$ ' is replaced by ' $V_s + f \times V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} \times \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \times \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0310382\text{E-}011$

$\nu_u = 3.3940726\text{E-}031$

$d = 0.8 \times D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \frac{1}{2} \times A_{\text{stirrup}} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $\text{Col}1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \frac{1}{2} \times A_{\text{stirrup}} = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $\text{Col}2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$b_w \times d = \frac{1}{4} \times d \times d = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \times V_{\text{Col}0}$

$V_{\text{Col}0} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \times f_y \times d / s$ ' is replaced by ' $V_s + f \times V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} \times \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \times \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0310382\text{E-}011$

$\nu_u = 3.3940726\text{E-}031$

$d = 0.8 \times D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \frac{1}{2} \times A_{\text{stirrup}} = 123370.055$

$f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = /2 * A_{stirrup} = 78956.835$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 457232.663$
 $b_w * d = *d * d / 4 = 125663.706$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcjcs

Constant Properties

Knowledge Factor, $= 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 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
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 781.25$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 781.25$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.36696
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = 300.00$
 No FRP Wrapping

Stepwise Properties

At local axis: 2
 EDGE -A-

Shear Force, $V_a = 1.5777218E-030$

EDGE -B-

Shear Force, $V_b = -1.5777218E-030$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{c,com} = 1017.876$

-Middle: $As_{mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6646E+008$

$M_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6646E+008$

$M_{u2+} = 1.6646E+008$, 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

$M_{u2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 1.6646E+008$

$\phi = 0.76794487$

$\phi' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$\phi' \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} * \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c' * c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b / l_d)^{2/3}) = 250.5135$
 $l_b / l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= * \text{Min}(1, 1.25 * (l_b / l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b / l_d

Lap Length: $l_b / l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} * \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of μ_2 +

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_2

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$

$db = 18.00$
Mean strength value of all re-bars: $fy = 781.25$
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = /2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{ColO}$

$V_{ColO} = 524225.731$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot fy \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$\nu_u = 1.5777218E-030$

$d = 0.8 \cdot D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = /2 \cdot A_{stirrup} = 123370.055$

$fy = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = /2 \cdot A_{stirrup} = 78956.835$

$fy = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$bw \cdot d = \cdot d \cdot d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{ColO}$

$V_{ColO} = 524225.731$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot fy \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$\nu_u = 1.5777218E-030$

$d = 0.8 \cdot D = 400.00$
 $Nu = 7389.214$
 $Ag = 196349.541$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 = 308425.138$
 $Vs1 = 308425.138$ is calculated for jacket, with:
 $Av = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $fy = 625.00$
 $s = 100.00$
 $Vs1$ is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $Vs2 = 0.00$ is calculated for core, with:
 $Av = \frac{1}{2} \cdot A_{stirrup} = 78956.835$
 $fy = 625.00$
 $s = 250.00$
 $Vs2$ is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 457232.663$
 $bw \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

 End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
 At local axis: 2

 Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
 At local axis: 3
 Integration Section: (a)
 Section Type: rcjcs

Constant Properties

 Knowledge Factor, $\gamma = 1.00$
 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:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_b = 300.00$
 No FRP Wrapping

 Stepwise Properties

 Bending Moment, $M = -1.4067E+007$
 Shear Force, $V2 = -4687.847$
 Shear Force, $V3 = -3.7842421E-013$
 Axial Force, $F = -7387.338$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_bL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00648247$

$u = y + p = 0.00648247$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00648247$ ((4.29), Biskinis Phd))

$M_y = 1.5355E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.769

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.3694E+013$

factor = 0.30

$A_g = 196349.541$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$

$N = 7387.338$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y,ten}, M_{y,com}) = 1.5355E+008$

$y = 4.4159581E-006$

$M_{y,ten} (8c) = 1.5355E+008$

$_{ten} (7c) = 64.86209$

error of function (7c) = 0.00290243

$M_{y,com} (8d) = 7.1091E+008$

$_{com} (7d) = 65.27569$

error of function (7d) = -0.00596423

with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.003125$

$e_{co} = 0.002$

$a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125411$

$N = 7387.338$

$A_c = 196349.541$

((10.1), ASCE 41-17) $= \min(, 1.25 * (I_b / I_d)^{2/3}) = 0.324$

with $f_c = 30.00$

Calculation of ratio I_b / I_d

Lap Length: $I_d / I_{d,min} = 0.16240769$

$I_b = 300.00$

$I_d = 1847.203$

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

$I_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} * \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

- Calculation of p -

From table 10-9: $p = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{ColOE} = 0.21168476$

$d = d_{\text{external}} = 0.00$

$s = s_{\text{external}} = 0.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00323428$

jacket: $s_1 = A_{v1} * (D_{c1} / 2) / (s_1 * A_g) = 0.0027646$

$A_{v1} = 78.53982$, is the area of stirrup

$D_{c1} = D_{\text{ext}} - 2 * \text{cover} - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading

(shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * (D_{c2} / 2) / (s_2 * A_g) = 0.00046968$

$A_{v2} = 50.26548$, is the area of stirrup

$D_{c2} = D_{\text{int}} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear)

direction

$s_2 = 250.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$NUD = 7387.338$

$A_g = 196349.541$

$f_{cE} = (f_{c_jacket} * \text{Area_jacket} + f_{c_core} * \text{Area_core}) / \text{section_area} = 30.00$

$f_{yIE} = (f_{y_ext_Long_Reinf} * \text{Area_ext_Long_Reinf} + f_{y_int_Long_Reinf} * \text{Area_int_Long_Reinf}) / \text{Area_Tot_Long_Rein} = 2.1219958E-314$

$f_{yTE} = (f_{y_ext_Trans_Reinf} * \text{Area_ext_Trans_Reinf} + f_{y_int_Trans_Reinf} * \text{Area_int_Trans_Reinf}) / \text{Area_Tot_Trans_Rein} = 625.00$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.015552$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

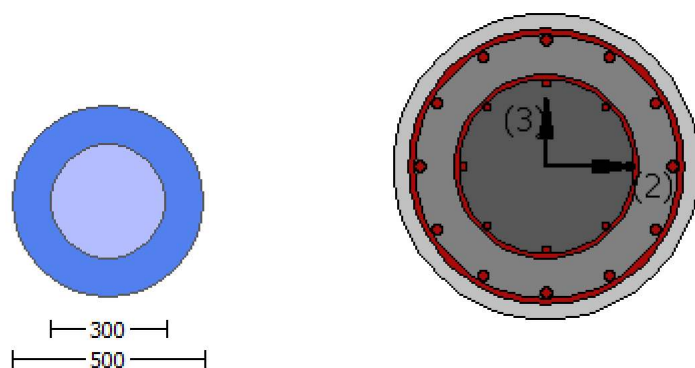
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = l_b = 300.00$
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.4067E+007$
Shear Force, $V_a = -4687.847$
EDGE -B-
Bending Moment, $M_b = 0.05009779$
Shear Force, $V_b = 4687.847$
BOTH EDGES
Axial Force, $F = -7387.338$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl} = 0.00$
-Compression: $A_{sc} = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1017.876$
-Compression: $A_{sl,com} = 1017.876$
-Middle: $A_{sl,mid} = 1017.876$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 423209.318$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 423209.318$
 $V_{CoI} = 423209.318$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.13740246$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_c_jacket \cdot Area_jacket + f'_c_core \cdot Area_core) / Area_section = 20.00$, but $f'_c^{0.5} \leq 8.3$
MPa ((22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.05009779$
 $V_u = 4687.847$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7387.338$
 $A_g = 196349.541$
From ((11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$
 $V_{s1} = 246740.11$ is calculated for jacket, with:
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From ((11-11), ACI 440: $V_s + V_f \leq 373328.906$
 $b_w \cdot d = \mu_u \cdot d \cdot d / 4 = 125663.706$

$displacement_ductility_demand$ is calculated as μ_y

- Calculation of ϕ_y for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta = 8.9047878E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00064808$ ((4.29), Biskinis Phd))
 $M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41-17: $E_{eff} = factor * E_c * I_g = 2.3694E+013$
factor = 0.30
 $A_g = 196349.541$
Mean concrete strength: $f'_c = (f'_{c_jacket} * Area_jacket + f'_{c_core} * Area_core) / Area_section = 30.00$
 $N = 7387.338$
 $E_c * I_g = E_{c_jacket} * I_{g_jacket} + E_{c_core} * I_{g_core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y_ten}, M_{y_com}) = 1.5355E+008$
 $y = 4.4159581E-006$
 $M_{y_ten} (8c) = 1.5355E+008$
 $y_{ten} (7c) = 64.86209$
error of function (7c) = 0.00290243
 $M_{y_com} (8d) = 7.1091E+008$
 $y_{com} (7d) = 65.27569$
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.003125$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125411$
 $N = 7387.338$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $\phi_y = \min(\phi_y, 1.25 * \phi_y * (l_b / l_d)^{2/3}) = 0.324$
with $f'_c = 30.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_{d,min} = 0.16240769$
 $l_b = 300.00$
 $l_d = 1847.203$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $\phi = 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} * Area_jacket + f'_{c_core} * Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \phi / 2 * Area \text{ of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

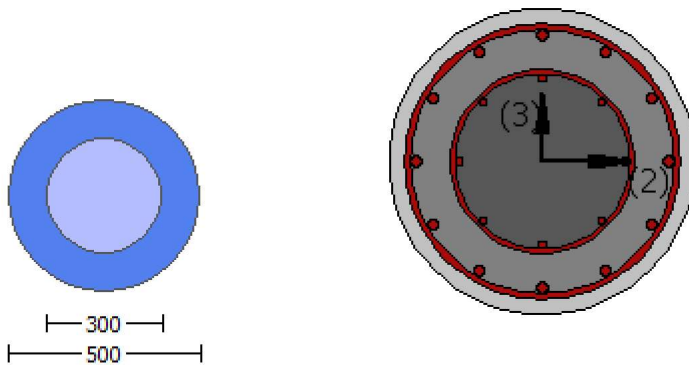
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.36696
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 3.3940726E-031$
EDGE -B-
Shear Force, $V_b = -3.3940726E-031$
BOTH EDGES
Axial Force, $F = -7389.214$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1017.876$
-Compression: $As_{c,com} = 1017.876$
-Middle: $As_{c,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6646E+008$
 $\mu_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6646E+008$
 $\mu_{u2+} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$\phi = 0.76794487$
 $\phi' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$

$$N = 7389.214$$

$$A_c = 196349.541$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$

$l_b = 300.00$

$d = 2309.004$

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

l_b ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of μ_1

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$\mu = 1.6646 \times 10^8$

$= 0.76794487$

$\mu' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 250.5135$

$l_b/d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$

$l_b = 300.00$

$d = 2309.004$

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

l_b ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

Ktr = 4.11234
Atr = $\sqrt{2}$ * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.10389295

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = $\sqrt{2}$ * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135

$l_b/l_d = 0.12992616$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= *Min(1, 1.25*(l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = /2 * \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 524225.731$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0310382E-011$

$V_u = 3.3940726E-031$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = /2 * A_{stirrup} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = /2 * A_{stirrup} = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$$bw*d = *d*d/4 = 125663.706$$

Calculation of Shear Strength at edge 2, $Vr2 = 524225.731$

$$Vr2 = VCol \text{ ((10.3), ASCE 41-17)} = knl * VCol0$$

$$VCol0 = 524225.731$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $Vs = Av*fy*d/s$ ' is replaced by ' $Vs + f*Vf$ ' where Vf is the contribution of FRPs (11.3), ACI 440).

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

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0310382E-011$$

$$V_u = 3.3940726E-031$$

$$d = 0.8 * D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

$$\text{From (11.5.4.8), ACI 318-14: } Vs = Vs1 + Vs2 = 308425.138$$

$Vs1 = 308425.138$ is calculated for jacket, with:

$$Av = /2 * A_{stirrup} = 123370.055$$

$$fy = 625.00$$

$$s = 100.00$$

$Vs1$ is multiplied by $Col1 = 1.00$

$$s/d = 0.25$$

$Vs2 = 0.00$ is calculated for core, with:

$$Av = /2 * A_{stirrup} = 78956.835$$

$$fy = 625.00$$

$$s = 250.00$$

$Vs2$ is multiplied by $Col2 = 0.00$

$$s/d = 1.04167$$

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

$$\text{From (11-11), ACI 440: } Vs + Vf \leq 457232.663$$

$$bw*d = *d*d/4 = 125663.706$$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $fc = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $fs = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $fc = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $fs = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

```

Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 781.25$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 781.25$ 
#####
External Diameter,  $D = 500.00$ 
Internal Diameter,  $D = 300.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.36696
Element Length,  $L = 3000.00$ 
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length  $l_o = 300.00$ 
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force,  $V_a = 1.5777218E-030$ 
EDGE -B-
Shear Force,  $V_b = -1.5777218E-030$ 
BOTH EDGES
Axial Force,  $F = -7389.214$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension:  $A_{st} = 0.00$ 
  -Compression:  $A_{sc} = 3053.628$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension:  $A_{st,ten} = 1017.876$ 
  -Compression:  $A_{st,com} = 1017.876$ 
  -Middle:  $A_{st,mid} = 1017.876$ 
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.21168476$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$ 
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.6646E+008$ 
   $Mu_{1+} = 1.6646E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
  which is defined for the static loading combination
   $Mu_{1-} = 1.6646E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
  direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.6646E+008$ 
   $Mu_{2+} = 1.6646E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
  which is defined for the the static loading combination
   $Mu_{2-} = 1.6646E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
  direction which is defined for the the static loading combination
-----

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

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd),  $Mu$ 
 $Mu = 1.6646E+008$ 
-----
  = 0.76794487
  ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY:  $f_{cc} = f_c^* \cdot c = 41.00884$ 
  conf. factor  $c = 1.36696$ 

```

$f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = /2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f'_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 4.11234$$

$$A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$$

$$s = s_{\text{external}} = 100.00$$

$$n = 12.00$$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u

$$\mu_u = 1.6646 \times 10^8$$

$$= 0.76794487$$

$$\lambda = 0.68333426$$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot \lambda = 41.00884$

$$\text{conf. factor } \lambda = 1.36696$$

$$f_c = 30.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b / l_d)^{2/3}) = 250.5135$

$$l_b / l_d = 0.12992616$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00125393$$

$$N = 7389.214$$

$$A_c = 196349.541$$

$$= \lambda \cdot \text{Min}(1, 1.25 \cdot (l_b / l_d)^{2/3}) = 0.10389295$$

Calculation of ratio l_b / l_d

Lap Length: $l_b / l_d = 0.12992616$

$$l_b = 300.00$$

$$l_d = 2309.004$$

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

l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 4.11234$$

$$A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$$

$$s = s_{\text{external}} = 100.00$$

$$n = 12.00$$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u

$$\mu_u = 1.6646 \times 10^8$$

$$= 0.76794487$$

$\rho = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$
 $V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE 41-17}) = k_{nl} \cdot V_{\text{ColO}}$
 $V_{\text{ColO}} = 524225.731$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.6629350E-011$
 $\nu_u = 1.5777218E-030$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:
 $A_v = \pi/2 \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \pi/2 \cdot A_{\text{stirrup}} = 78956.835$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.04167$$

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

From (11-11), ACI 440: Vs + Vf <= 457232.663

$$bw*d = *d*d/4 = 125663.706$$

Calculation of Shear Strength at edge 2, Vr2 = 524225.731

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

$$VCol0 = 524225.731$$

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1.6629350E-011$$

$$V_u = 1.5777218E-030$$

$$d = 0.8*D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138

Vs1 = 308425.138 is calculated for jacket, with:

$$A_v = /2*A_stirrup = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.25$$

Vs2 = 0.00 is calculated for core, with:

$$A_v = /2*A_stirrup = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.04167$$

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

From (11-11), ACI 440: Vs + Vf <= 457232.663

$$bw*d = *d*d/4 = 125663.706$$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00

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:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 30.00

New material of Primary Member: Steel Strength, fs = fsm = 625.00

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 8.5635974E-011$
 Shear Force, $V_2 = 4687.847$
 Shear Force, $V_3 = 3.7842421E-013$
 Axial Force, $F = -7387.338$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3053.628$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1017.876$
 -Compression: $A_{st,com} = 1017.876$
 -Middle: $A_{st,mid} = 1017.876$
 Mean Diameter of Tension Reinforcement, $D_bL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.0032404$
 $u = y + p = 0.0032404$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.0032404 ((4.29), \text{Biskinis Phd})$
 $M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) $= 1500.00$
 From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 2.3694E+013$
 factor = 0.30
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$
 $N = 7387.338$
 $E_c * I_g = E_{c,\text{jacket}} * I_{g,\text{jacket}} + E_{c,\text{core}} * I_{g,\text{core}} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y,\text{ten}}, M_{y,\text{com}}) = 1.5355E+008$
 $y = 4.4159581E-006$
 $M_{y,\text{ten}} (8c) = 1.5355E+008$
 $_{\text{ten}} (7c) = 64.86209$
 error of function (7c) = 0.00290243
 $M_{y,\text{com}} (8d) = 7.1091E+008$
 $_{\text{com}} (7d) = 65.27569$
 error of function (7d) = -0.00596423
 with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.003125$
 $e_{co} = 0.002$

$\alpha_l = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125411$
 $N = 7387.338$
 $A_c = 196349.541$
 $((10.1), ASCE 41-17) = \text{Min}(, 1.25 * (l_b/l_d)^{2/3}) = 0.324$
 with $f_c = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.16240769$

$l_b = 300.00$

$l_d = 1847.203$

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

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 * \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

- Calculation of ρ -

From table 10-9: $\rho = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{col} O E = 0.21168476$

$d = d_{external} = 0.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00323428$

jacket: $s_1 = A_{v1} * (\pi * D_c / 2) / (s_1 * A_g) = 0.0027646$

$A_{v1} = 78.53982$, is the area of stirrup

$D_c1 = D_{ext} - 2 * \text{cover} - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * (\pi * D_c / 2) / (s_2 * A_g) = 0.00046968$

$A_{v2} = 50.26548$, is the area of stirrup

$D_c2 = D_{int} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear) direction

direction

$s_2 = 250.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$N_{UD} = 7387.338$

$A_g = 196349.541$

$f_{cE} = (f_{c,jacket} * \text{Area}_{jacket} + f_{c,core} * \text{Area}_{core}) / \text{section_area} = 30.00$

$f_{yLE} = (f_{y,ext_Long_Reinf} * \text{Area}_{ext_Long_Reinf} + f_{y,int_Long_Reinf} * \text{Area}_{int_Long_Reinf}) / \text{Area}_{Tot_Long_Rein} = 21219958E-314$

$f_{yTE} = (f_{y,ext_Trans_Reinf} * \text{Area}_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} * \text{Area}_{int_Trans_Reinf}) / \text{Area}_{Tot_Trans_Rein} = 625.00$

$\rho_l = \text{Area}_{Tot_Long_Rein} / (A_g) = 0.015552$

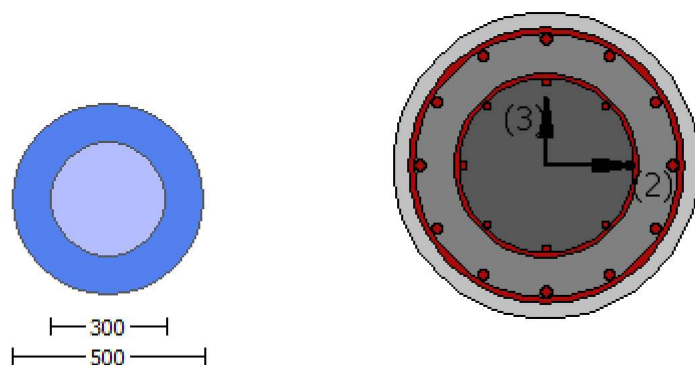
$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity V_{Rd}
Edge: End
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3
Integration Section: (b)
Section Type: rcjs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as

Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 1.0499072E-009$

Shear Force, $V_a = -3.7842421E-013$

EDGE -B-

Bending Moment, $M_b = 8.5635974E-011$

Shear Force, $V_b = 3.7842421E-013$

BOTH EDGES

Axial Force, $F = -7387.338$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{st,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 423209.318$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 423209.318$

$V_{CoI} = 423209.318$

$k_n = 1.00$

displacement_ductility_demand = 0.00

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 20.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / V_d = 2.00$

$M_u = 8.5635974E-011$

$V_u = 3.7842421E-013$

$d = 0.8 \cdot D = 400.00$

$N_u = 7387.338$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$

$V_{s1} = 246740.11$ is calculated for jacket, with:

$A_v = /2 \cdot A_{stirrup} = 123370.055$

$f_y = 500.00$

$s = 100.00$

V_{s1} is multiplied by $CoI1 = 1.00$

$s/d = 0.25$
 $Vs2 = 0.00$ is calculated for core, with:
 $Av = \pi/2 \cdot A_{stirrup} = 78956.835$
 $fy = 500.00$
 $s = 250.00$
 $Vs2$ is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 373328.906$
 $bw \cdot d = \pi \cdot d \cdot d / 4 = 125663.706$

displacement_ductility_demand is calculated as δ / y

- Calculation of δ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 5.3141893E-021$
 $y = (My \cdot Ls / 3) / Eleff = 0.0032404 ((4.29), Biskinis Phd)$
 $My = 1.5355E+008$
 $Ls = M/V$ (with $Ls > 0.1 \cdot L$ and $Ls < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41_17: $Eleff = factor \cdot Ec \cdot Ig = 2.3694E+013$
 $factor = 0.30$
 $Ag = 196349.541$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7387.338$
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 7.8978E+013$

Calculation of Yielding Moment My

Calculation of δ and My according to (7) - (8) in Biskinis and Fardis

$My = \min(My_{ten}, My_{com}) = 1.5355E+008$
 $y = 4.4159581E-006$
 $My_{ten} (8c) = 1.5355E+008$
 $_{ten} (7c) = 64.86209$
 error of function (7c) = 0.00290243
 $My_{com} (8d) = 7.1091E+008$
 $_{com} (7d) = 65.27569$
 error of function (7d) = -0.00596423
 with ((10.1), ASCE 41-17) $ey = \min(ey, 1.25 \cdot ey \cdot (lb/d)^{2/3}) = 0.003125$
 $eco = 0.002$
 $apl = 0.35 ((9a) \text{ in Biskinis and Fardis for no FRP Wrap})$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00125411$
 $N = 7387.338$
 $Ac = 196349.541$
 ((10.1), ASCE 41-17) $= \min(, 1.25 \cdot (lb/d)^{2/3}) = 0.324$
 with $fc = 30.00$

Calculation of ratio lb/d

Lap Length: $ld/d, \min = 0.16240769$
 $lb = 300.00$
 $ld = 1847.203$
 Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $fy = 625.00$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \frac{1}{2} \times \text{Area of external stirrup} = 123.3701$

$s_{\text{external}} = 100.00$

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

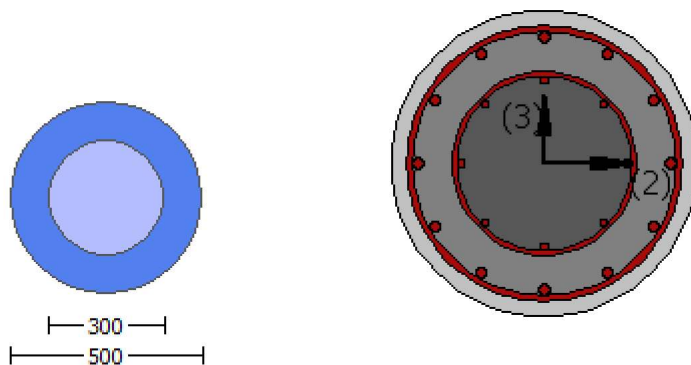
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

```

Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
#####
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
-----
-----

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
-----

Calculation of Mu1+
-----

```

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^ 2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/ld)^ 2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^ 2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/ld)^ 2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f'_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

$$\text{Mu} = 1.6646\text{E}+008$$

$$= 0.76794487$$

$$' = 0.68333426$$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

$$\text{conf. factor } c = 1.36696$$

$$f_c = 30.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$$l_b/l_d = 0.12992616$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00125393$$

$$N = 7389.214$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$$l_b = 300.00$$

$$l_d = 2309.004$$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 4.11234$$

$$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$$

$$s = s_{\text{external}} = 100.00$$

$$n = 12.00$$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$$V_{r1} = V_{\text{Col}} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{\text{ColO}}$$

$$V_{\text{ColO}} = 524225.731$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ '

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

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

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\text{Mu} = 2.0310382\text{E}-011$$

$$V_u = 3.3940726\text{E}-031$$

$$d = 0.8 \cdot D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$$A_v = \frac{1}{2} A_{stirrup} = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.25$$

$V_{s2} = 0.00$ is calculated for core, with:

$$A_v = \frac{1}{2} A_{stirrup} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

V_{s2} is multiplied by $Col2 = 0.00$

$$s/d = 1.04167$$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$$b_w d = \frac{1}{4} d^2 = 125663.706$$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I V_{Col0}$

$$V_{Col0} = 524225.731$$

$k_n I = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d / s$ ' is replaced by ' $V_s + f V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c \text{ jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \text{ core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0310382E-011$$

$$\nu_u = 3.3940726E-031$$

$$d = 0.8 D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$$A_v = \frac{1}{2} A_{stirrup} = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.25$$

$V_{s2} = 0.00$ is calculated for core, with:

$$A_v = \frac{1}{2} A_{stirrup} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

V_{s2} is multiplied by $Col2 = 0.00$

$$s/d = 1.04167$$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$$b_w d = \frac{1}{4} d^2 = 125663.706$$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
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
Jacket
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
Existing Column
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

External Diameter, $D = 500.00$
Internal Diameter, $D = 300.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.36696
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.5777218E-030$
EDGE -B-
Shear Force, $V_b = -1.5777218E-030$
BOTH EDGES
Axial Force, $F = -7389.214$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1017.876$
-Compression: $A_{sl,com} = 1017.876$
-Middle: $A_{sl,mid} = 1017.876$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.21168476$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.6646E+008$
 $Mu_{1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $Mu_{1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.6646E+008$
 $Mu_{2+} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the static loading combination
 $Mu_{2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.10389295

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393

$$N = 7389.214$$

$$A_c = 196349.541$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$

$l_b = 300.00$

$d = 2309.004$

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

l_b ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$\mu = 1.6646 \times 10^8$

$= 0.76794487$

$\mu' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 250.5135$

$l_b/d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$

$l_b = 300.00$

$d = 2309.004$

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

l_b ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.10389295

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu_u = 1.6629350E-011$
 $\mu_v = 1.5777218E-030$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 457232.663$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} \cdot V_{Col0}$
 $V_{Col0} = 524225.731$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu_u = 1.6629350E-011$
 $\mu_v = 1.5777218E-030$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 457232.663$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
 At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
 At local axis: 3

Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 0.05009779$

Shear Force, $V_2 = 4687.847$

Shear Force, $V_3 = 3.7842421E-013$

Axial Force, $F = -7387.338$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{l,com} = 1017.876$

-Middle: $As_{l,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_L = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00064808$

$u = \gamma + \rho = 0.00064808$

- Calculation of γ -

$\gamma = (M \gamma_L / 3) / E_{eff} = 0.00064808$ ((4.29), Biskinis Phd))

$M \gamma = 1.5355E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 2.3694E+013$

factor = 0.30

$A_g = 196349.541$

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$

$N = 7387.338$

$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y_ten}, M_{y_com}) = 1.5355E+008$
 $\rho_y = 4.4159581E-006$
 $M_{y_ten} (8c) = 1.5355E+008$
 $\rho_{y_ten} (7c) = 64.86209$
error of function (7c) = 0.00290243
 $M_{y_com} (8d) = 7.1091E+008$
 $\rho_{y_com} (7d) = 65.27569$
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) $\rho_{ey} = \min(\rho_y, 1.25 \cdot \rho_y \cdot (l_b/l_d)^{2/3}) = 0.003125$
 $\rho_{eco} = 0.002$
 $\rho_{apl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125411$
 $N = 7387.338$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $\rho_{fc} = \min(\rho_y, 1.25 \cdot \rho_y \cdot (l_b/l_d)^{2/3}) = 0.324$
with $f_c = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_d, \min = 0.16240769$
 $l_b = 300.00$
 $l_d = 1847.203$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $\rho = 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

- Calculation of ρ_p -

From table 10-9: $\rho_p = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$
shear control ratio $V_y E / V_{col} O E = 0.21168476$
 $d = d_{external} = 0.00$
 $s = s_{external} = 0.00$
 $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00323428$
jacket: $s_1 = A_{v1} \cdot (\pi \cdot D_{c1} / 2) / (s_1 \cdot A_g) = 0.0027646$
 $A_{v1} = 78.53982$, is the area of stirrup
 $D_{c1} = D_{ext} - 2 \cdot \text{cover} - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s_1 = 100.00$
core: $s_2 = A_{v2} \cdot (\pi \cdot D_{c2} / 2) / (s_2 \cdot A_g) = 0.00046968$
 $A_{v2} = 50.26548$, is the area of stirrup
 $D_{c2} = D_{int} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s_2 = 250.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength. All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$N_{UD} = 7387.338$$

$$A_g = 196349.541$$

$$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 30.00$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 21219958E-314$$

$$f_{yTE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 625.00$$

$$\rho_l = Area_Tot_Long_Rein / (A_g) = 0.015552$$

$$f_{cE} = 30.00$$

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

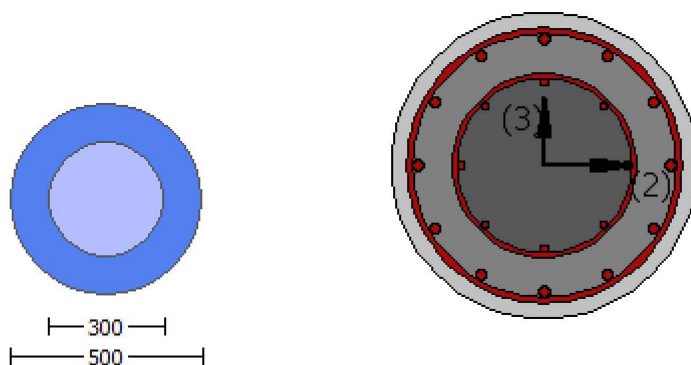
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -2.2226E+007$

Shear Force, $V_a = -7406.71$

EDGE -B-

Bending Moment, $M_b = 0.07915355$

Shear Force, $V_b = 7406.71$

BOTH EDGES

Axial Force, $F = -7386.251$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 1272.345$

-Compression: $A_{sl,c} = 1781.283$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1017.876$

-Compression: $A_{sl,com} = 1017.876$

-Middle: $A_{sl,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 334974.606$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 334974.606$

$V_{CoI} = 334974.606$

$k_n = 1.00$

displacement_ductility_demand = 0.03985963

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 20.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 2.2226E+007$
 $V_u = 7406.71$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7386.251$
 $A_g = 196349.541$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$
 $V_{s1} = 246740.11$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 373328.906$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

displacement ductility demand is calculated as δ_u / y

- Calculation of δ_u / y for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation $\theta_r = 0.00025839$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00648246$ ((4.29), Biskinis Phd))
 $M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.769
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.3694E+013$
 $factor = 0.30$
 $A_g = 196349.541$
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7386.251$
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of δ_u and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y,ten}, M_{y,com}) = 1.5355E+008$
 $y = 4.4159560E-006$
 $M_{y,ten} (8c) = 1.5355E+008$
 $\delta_{u,ten} (7c) = 64.86205$
error of function (7c) = 0.00290247
 $M_{y,com} (8d) = 7.1091E+008$
 $\delta_{u,com} (7d) = 65.27568$
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 \cdot e_y \cdot (l_b/l_d)^{2/3}) = 0.003125$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7386.251$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $\phi = \min(\phi, 1.25 \cdot \phi \cdot (l_b/l_d)^{2/3}) = 0.324$

with $f_c = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.16240769$

$l_b = 300.00$

$l_d = 1847.203$

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

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

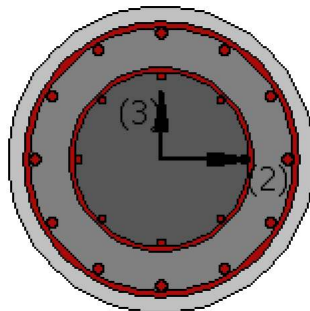
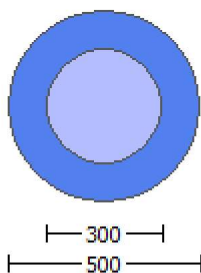
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.36696

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.3940726E-031$

EDGE -B-

Shear Force, $V_b = -3.3940726E-031$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{l,com} = 1017.876$

-Middle: $As_{l,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$

with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6646E+008$
 $M_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $M_{u1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6646E+008$
 $M_{u2+} = 1.6646E+008$, 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
 $M_{u2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 1.6646E+008$

$\phi = 0.76794487$
 $\lambda = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TB DY: $f_{cc} = f_c \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 1.6646E+008$

$\phi = 0.76794487$

$\rho = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$\rho = 0.76794487$
 $\rho = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 524225.731$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0310382E-011$

$\nu_u = 3.3940726E-031$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = /2 * A_stirrup = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = /2 * A_stirrup = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$bw * d = *d * d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 524225.731$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0310382E-011$

$\nu_u = 3.3940726E-031$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = /2 * A_stirrup = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = /2 * A_stirrup = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$bw * d = *d * d / 4 = 125663.706$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.36696

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.5777218E-030$

EDGE -B-

Shear Force, $V_b = -1.5777218E-030$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1017.876$

-Compression: $As_{l,com} = 1017.876$

-Middle: $As_{l,mid} = 1017.876$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.21168476$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6646E+008$

$M_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6646E+008$

$M_{u2+} = 1.6646E+008$, 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

$M_{u2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 1.6646E+008$

$= 0.76794487$

$' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 1.6646E+008

= 0.76794487

' = 0.68333426

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 1.6646E+008

= 0.76794487

' = 0.68333426

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

Calculation of μ_2

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$\mu = 1.6646E+008$

$= 0.76794487$

$' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f'_c \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$= \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{ColO}$

$V_{ColO} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$\nu_u = 1.5777218E-030$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \sqrt{2} * A_{stirrup} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \sqrt{2} * A_{stirrup} = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$b_w * d = \sqrt{2} * d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{ColO}$

$V_{ColO} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$\nu_u = 1.5777218E-030$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \sqrt{2} * A_{stirrup} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \sqrt{2} * A_{stirrup} = 78956.835$

$f_y = 625.00$

$s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 457232.663$
 $bw*d = *d*d/4 = 125663.706$

 End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
 At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
 At local axis: 2
 Integration Section: (a)
 Section Type: rcjcs

Constant Properties

 Knowledge Factor, $\gamma = 1.00$
 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:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

 Bending Moment, $M = 1.6470537E-009$
 Shear Force, $V_2 = -7406.71$
 Shear Force, $V_3 = -5.9790306E-013$
 Axial Force, $F = -7386.251$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1272.345$
 -Compression: $As_c = 1781.283$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{l,ten} = 1017.876$
 -Compression: $As_{l,com} = 1017.876$
 -Middle: $As_{l,mid} = 1017.876$
 Mean Diameter of Tension Reinforcement, $Db_L = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^* u = 0.03285837$

$$u = y + p = 0.03285837$$

- Calculation of y -

$$y = (My \cdot L_s / 3) / E_{eff} = 0.0032404 \text{ ((4.29), Biskinis Phd)}$$

$$My = 1.5355E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 \cdot L \text{ and } L_s < 2 \cdot L) = 1500.00$$

$$\text{From table 10.5, ASCE 41-17: } E_{eff} = \text{factor} \cdot E_c \cdot I_g = 2.3694E+013$$

$$\text{factor} = 0.30$$

$$A_g = 196349.541$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$$

$$N = 7386.251$$

$$E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 7.8978E+013$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$$M_y = \min(M_{y_{\text{ten}}}, M_{y_{\text{com}}}) = 1.5355E+008$$

$$y = 4.4159560E-006$$

$$M_{y_{\text{ten}}} (8c) = 1.5355E+008$$

$$_{\text{ten}} (7c) = 64.86205$$

$$\text{error of function (7c)} = 0.00290247$$

$$M_{y_{\text{com}}} (8d) = 7.1091E+008$$

$$_{\text{com}} (7d) = 65.27568$$

$$\text{error of function (7d)} = -0.00596425$$

$$\text{with ((10.1), ASCE 41-17) } e_y = \min(e_y, 1.25 \cdot e_y \cdot (l_b / l_d)^{2/3}) = 0.003125$$

$$e_{co} = 0.002$$

$$a_{pl} = 0.35 \text{ ((9a) in Biskinis and Fardis for no FRP Wrap)}$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00125393$$

$$N = 7386.251$$

$$A_c = 196349.541$$

$$((10.1), \text{ASCE 41-17}) = \min(, 1.25 \cdot (l_b / l_d)^{2/3}) = 0.324$$

$$\text{with } f_c = 30.00$$

Calculation of ratio l_b / l_d

$$\text{Lap Length: } l_d / l_{d,\min} = 0.16240769$$

$$l_b = 300.00$$

$$l_d = 1847.203$$

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

$l_{d,\min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$$= 1$$

$$d_b = 18.00$$

$$\text{Mean strength value of all re-bars: } f_y = 625.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 4.11234$$

$$A_{tr} = \pi / 2 \cdot \text{Area of external stirrup} = 123.3701$$

$$s = s_{\text{external}} = 100.00$$

$$n = 12.00$$

- Calculation of p -

$$\text{From table 10-9: } p = 0.02961797$$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_{yE}/V_{ColOE} = 0.21168476$

$d = d_{external} = 0.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2*tf/bw*(f_{fe}/f_s) = 0.00323428$

jacket: $s_1 = A_{v1}*(Dc1/2)/(s_1*Ag) = 0.0027646$

$A_{v1} = 78.53982$, is the area of stirrup

$Dc1 = D_{ext} - 2*cover - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2}*(Dc2/2)/(s_2*Ag) = 0.00046968$

$A_{v2} = 50.26548$, is the area of stirrup

$Dc2 = D_{int} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

The term $2*tf/bw*(f_{fe}/f_s)$ is implemented to account for FRP contribution where $f = 2*tf/bw$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe}/f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$NUD = 7386.251$

$Ag = 196349.541$

$f_{cE} = (f_{c,jacket}*Area_{jacket} + f_{c,core}*Area_{core})/section_area = 30.00$

$f_{yIE} = (f_{y,ext_Long_Reinf}*Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf}*Area_{int_Long_Reinf})/Area_{Tot_Long_Rein} = 2.1219958E-314$

$f_{yTE} = (f_{y,ext_Trans_Reinf}*Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf}*Area_{int_Trans_Reinf})/Area_{Tot_Trans_Rein} = 625.00$

$pI = Area_{Tot_Long_Rein}/(Ag) = 0.015552$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

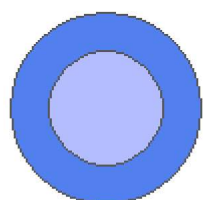
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

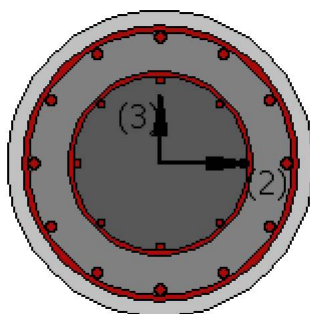
Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



300
500



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 1.6470537E-009$

Shear Force, $V_a = -5.9790306E-013$

EDGE -B-

Bending Moment, $M_b = 1.4708285E-010$

Shear Force, $V_b = 5.9790306E-013$
 BOTH EDGES
 Axial Force, $F = -7386.251$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1272.345$
 -Compression: $As_c = 1781.283$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1017.876$
 -Compression: $As_{c,com} = 1017.876$
 -Middle: $As_{mid} = 1017.876$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 423209.102$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col0} = 423209.102$
 $V_{Col} = 423209.102$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs ((11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c_jacket \cdot Area_jacket + f'_c_core \cdot Area_core) / Area_section = 20.00$, but $f'_c^{0.5} \leq 8.3$
 MPa ((22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.6470537E-009$
 $V_u = 5.9790306E-013$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7386.251$
 $A_g = 196349.541$
 From ((11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$
 $V_{s1} = 246740.11$ is calculated for jacket, with:
 $A_v = \sqrt{2} \cdot A_stirrup = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_stirrup = 78956.835$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From ((11-11), ACI 440: $V_s + V_f \leq 373328.906$
 $b_w \cdot d = \sqrt{2} \cdot d^2 / 4 = 125663.706$

$displacement_ductility_demand$ is calculated as ϕ / y

- Calculation of ϕ / y for END A -
 for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 1.9398072E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.0032404$ ((4.29), Biskinis Phd))
 $M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.3694E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_c_jacket \cdot Area_jacket + f'_c_core \cdot Area_core) / Area_section = 30.00$
 $N = 7386.251$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y_ten}, M_{y_com}) = 1.5355E+008$

$y = 4.4159560E-006$

$M_{y_ten} (8c) = 1.5355E+008$

$_{y_ten} (7c) = 64.86205$

error of function (7c) = 0.00290247

$M_{y_com} (8d) = 7.1091E+008$

$_{y_com} (7d) = 65.27568$

error of function (7d) = -0.00596425

with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (l_b/l_d)^{2/3}) = 0.003125$

$e_{co} = 0.002$

$a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7386.251$

$A_c = 196349.541$

((10.1), ASCE 41-17) $= \min(, 1.25 * (l_b/l_d)^{2/3}) = 0.324$

with $f_c = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_d, \min = 0.16240769$

$l_b = 300.00$

$l_d = 1847.203$

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

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f'_c = (f'_{c_jacket} * Area_{jacket} + f'_{c_core} * Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 * Area_{external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

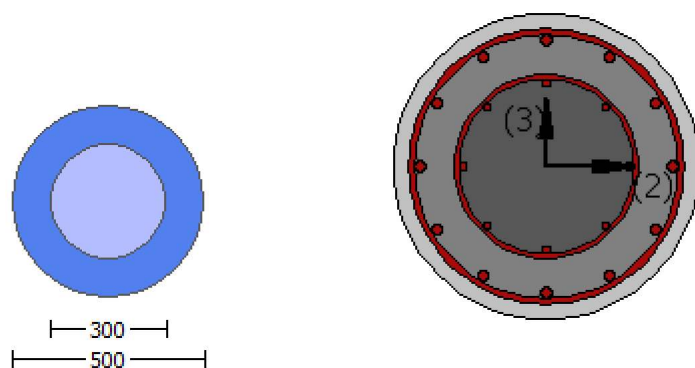
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.36696

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 3.3940726E-031$

EDGE -B-

Shear Force, $V_b = -3.3940726E-031$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{l,com} = 1017.876$

-Middle: $As_{l,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.6646E+008$

$Mu_{1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.6646E+008$

$Mu_{2+} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 1.6646E+008$

$\phi = 0.76794487$

$\phi' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$= \phi' \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 4.11234$$

$$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$$

$$s = s_{external} = 100.00$$

$$n = 12.00$$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$$= 0.76794487$$

$$\gamma = 0.68333426$$

error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f_c' \cdot \gamma = 41.00884$
conf. factor $\gamma = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \gamma \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 4.11234$$

$$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$$

$$s = s_{external} = 100.00$$

$$n = 12.00$$

Calculation of μ_2 +

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^ 2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/ld)^ 2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^ 2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/ld)^ 2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $d_b = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$

$V_{Col0} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0310382E-011$

$V_u = 3.3940726E-031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \sqrt{2} \cdot A_{stirrup} = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$

$V_{Col0} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 2.0310382\text{E}-011$
 $V_u = 3.3940726\text{E}-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 78956.835$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 457232.663$
 $b_w \cdot d = \frac{1}{4} \cdot d^2 = 125663.706$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.36696

Element Length, $L = 3000.00$

Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.5777218E-030$
EDGE -B-
Shear Force, $V_b = -1.5777218E-030$
BOTH EDGES
Axial Force, $F = -7389.214$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1017.876$
-Compression: $As_{c,com} = 1017.876$
-Middle: $As_{c,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$
with
 $M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.6646E+008$
 $\mu_{1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.6646E+008$
 $\mu_{2+} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$\phi = 0.76794487$
 $\phi' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $\phi' \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$\mu = 1.6646 \times 10^8$

$= 0.76794487$

$' = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.10389295

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393

$$N = 7389.214$$

$$A_c = 196349.541$$

$$= *Min(1, 1.25 * (l_b / d)^{2/3}) = 0.10389295$$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$

$l_b = 300.00$

$d = 2309.004$

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

l_b , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} * A_{\text{jacket}} + f'_c_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 * \text{Area of external stirrup} = 123.3701$

$s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$

$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Co10}$

$V_{Co10} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} * A_{\text{jacket}} + f'_c_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 1.6629350E-011$

$V_u = 1.5777218E-030$

$d = 0.8 * D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \pi/2 * A_{\text{stirrup}} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \pi/2 * A_{\text{stirrup}} = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$b_w * d = \pi * d^2 / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 524225.731

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.6629350E-011

Vu = 1.5777218E-030

d = 0.8*D = 400.00

Nu = 7389.214

Ag = 196349.541

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138

Vs1 = 308425.138 is calculated for jacket, with:

Av = /2*A_stirrup = 123370.055

fy = 625.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.25

Vs2 = 0.00 is calculated for core, with:

Av = /2*A_stirrup = 78956.835

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.04167

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

From (11-11), ACI 440: Vs + Vf <= 457232.663

bw*d = *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00

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:

Jacket

New material of Primary Member: Concrete Strength, $fc = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $fs = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $fc = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $fs = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Diameter, D = 500.00

Internal Diameter, D = 300.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -2.2226E+007$

Shear Force, $V_2 = -7406.71$

Shear Force, $V_3 = -5.9790306E-013$

Axial Force, $F = -7386.251$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1272.345$

-Compression: $As_c = 1781.283$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{ten} = 1017.876$

-Compression: $As_{com} = 1017.876$

-Middle: $As_{mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_L = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03610043$

$u = y + p = 0.03610043$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00648246$ ((4.29), Biskinis Phd))

$M_y = 1.5355E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.769

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.3694E+013$

factor = 0.30

$A_g = 196349.541$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$

$N = 7386.251$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y,ten}, M_{y,com}) = 1.5355E+008$

$y = 4.4159560E-006$

$M_{y,ten} (8c) = 1.5355E+008$

$_{ten} (7c) = 64.86205$

error of function (7c) = 0.00290247

$M_{y,com} (8d) = 7.1091E+008$

$_{com} (7d) = 65.27568$

error of function (7d) = -0.00596425

with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.003125$

$e_{co} = 0.002$

$a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7386.251$

$A_c = 196349.541$

((10.1), ASCE 41-17) $= \min(, 1.25 * (l_b / l_d)^{2/3}) = 0.324$

with $fc = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.16240769$

$l_b = 300.00$

$l_d = 1847.203$

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

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/4 \cdot Area \text{ of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

- Calculation of p -

From table 10-9: $p = 0.02961797$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{col} E = 0.21168476$

$d = d_{external} = 0.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00323428$

jacket: $s_1 = A_{v1} \cdot (\pi \cdot D_{c1} / 2) / (s_1 \cdot A_g) = 0.0027646$

$A_{v1} = 78.53982$, is the area of stirrup

$D_{c1} = D_{ext} - 2 \cdot cover - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot (\pi \cdot D_{c2} / 2) / (s_2 \cdot A_g) = 0.00046968$

$A_{v2} = 50.26548$, is the area of stirrup

$D_{c2} = D_{int} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$N_{UD} = 7386.251$

$A_g = 196349.541$

$f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section_area = 30.00$

$f_{yE} = (f_{y,ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 21219958E-314$

$f_{yE} = (f_{y,ext_Trans_Reinf} \cdot Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} = 625.00$

$p_l = Area_{Tot_Long_Rein} / (A_g) = 0.015552$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

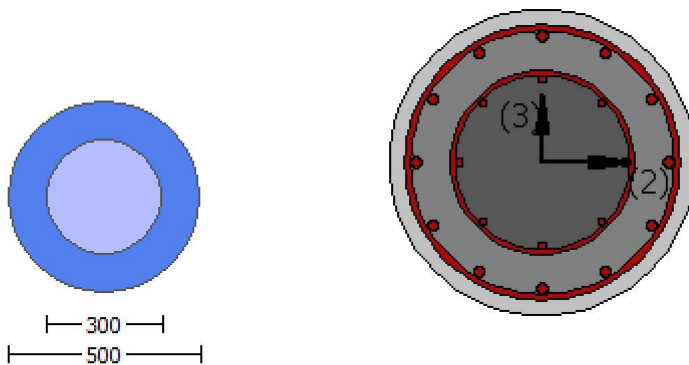
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

External Diameter, D = 500.00
 Internal Diameter, D = 300.00
 Cover Thickness, c = 25.00
 Element Length, L = 3000.00
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -2.2226E+007$
 Shear Force, $V_a = -7406.71$
 EDGE -B-
 Bending Moment, $M_b = 0.07915355$
 Shear Force, $V_b = 7406.71$
 BOTH EDGES
 Axial Force, $F = -7386.251$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3053.628$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1017.876$
 -Compression: $A_{sl,com} = 1017.876$
 -Middle: $A_{sl,mid} = 1017.876$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 423209.102$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col0} = 423209.102$
 $V_{Col} = 423209.102$
 $k_n = 1.00$
 displacement_ductility_demand = 0.21709356

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 20.00$, but $f'_c^{0.5} \leq 8.3$
 MPa ((22.5.3.1, ACI 318-14))
 $M/V_d = 2.00$
 $\mu_u = 0.07915355$
 $V_u = 7406.71$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7386.251$
 $A_g = 196349.541$
 From ((11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$
 $V_{s1} = 246740.11$ is calculated for jacket, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 373328.906$
 $b_w \cdot d = \frac{V_s \cdot d}{4} = 125663.706$

displacement_ductility_demand is calculated as $\frac{M}{y}$

- Calculation of $\frac{M}{y}$ for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta = 0.00014069$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00064808$ ((4.29), Biskinis Phd))
 $M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.3694E+013$
factor = 0.30
 $A_g = 196349.541$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 30.00$
 $N = 7386.251$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of $\frac{M}{y}$ and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y_ten}, M_{y_com}) = 1.5355E+008$
 $y = 4.4159560E-006$
 $M_{y_ten} (8c) = 1.5355E+008$
 $\frac{M}{y} (7c) = 64.86205$
error of function (7c) = 0.00290247
 $M_{y_com} (8d) = 7.1091E+008$
 $\frac{M}{y} (7d) = 65.27568$
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 \cdot e_y \cdot (l_b / l_d)^{2/3}) = 0.003125$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7386.251$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $\phi = \min(\phi, 1.25 \cdot \phi \cdot (l_b / l_d)^{2/3}) = 0.324$
with $f'_c = 30.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_d, \min = 0.16240769$
 $l_b = 300.00$
 $l_d = 1847.203$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $\phi = 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$

n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 14

column C1, Floor 1

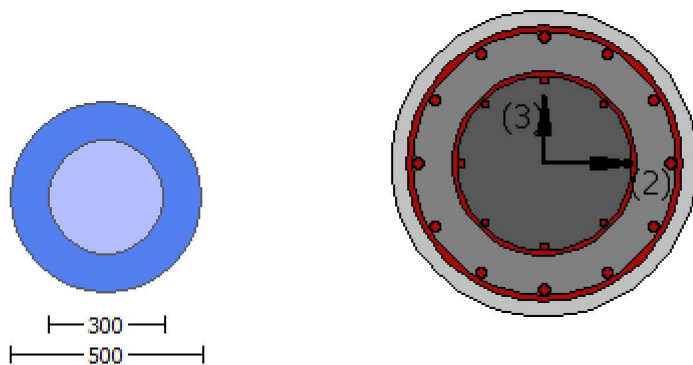
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 781.25$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 781.25$ 
#####
External Diameter,  $D = 500.00$ 
Internal Diameter,  $D = 300.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.36696
Element Length,  $L = 3000.00$ 
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length  $l_o = 300.00$ 
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = 3.3940726E-031$ 
EDGE -B-
Shear Force,  $V_b = -3.3940726E-031$ 
BOTH EDGES
Axial Force,  $F = -7389.214$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension:  $A_{st} = 0.00$ 
  -Compression:  $A_{sc} = 3053.628$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension:  $A_{st,ten} = 1017.876$ 
  -Compression:  $A_{st,com} = 1017.876$ 
  -Middle:  $A_{st,mid} = 1017.876$ 
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.21168476$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$ 
with
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.6646E+008$ 
 $\mu_{u1+} = 1.6646E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 1.6646E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 1.6646E+008$ 
 $\mu_{u2+} = 1.6646E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 1.6646E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
-----

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

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd),  $\mu_u$ 
 $\mu_u = 1.6646E+008$ 
-----
= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY:  $f_{cc} = f_c \cdot c = 41.00884$ 

```

conf. factor $c = 1.36696$
 $fc = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 250.5135$
 $lb/ld = 0.12992616$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 0.10389295$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.12992616$
 $lb = 300.00$
 $ld = 2309.004$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = /2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = fc \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $fc = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 250.5135$
 $lb/ld = 0.12992616$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 0.10389295$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.12992616$
 $lb = 300.00$
 $ld = 2309.004$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TDY: $f_{cc} = f'_c \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 250.5135$
 $l_b/d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$\beta = 0.76794487$
 $\beta' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f_c \cdot \beta = 41.00884$
conf. factor $\beta = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 250.5135$
 $l_b/d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$
 $l_b = 300.00$
 $d = 2309.004$
Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_b , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$
 $V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE 41-17}) = k_{nl} \cdot V_{\text{ColO}}$
 $V_{\text{ColO}} = 524225.731$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

$\beta = 1$ (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 2.0310382E-011$
 $\nu_u = 3.3940726E-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:
 $A_v = \pi/2 \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:

$$A_v = \frac{1}{2} A_{\text{stirrup}} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

$$V_{s2} \text{ is multiplied by } \text{Col2} = 0.00$$

$$s/d = 1.04167$$

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

$$\text{From } (11-11), \text{ACI } 440: V_s + V_f \leq 457232.663$$

$$b_w d = \frac{1}{4} d^2 = 125663.706$$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_n l V_{\text{ColO}}$$

$$V_{\text{ColO}} = 524225.731$$

$$k_n l = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v f_y d / s$ ' is replaced by ' $V_s + f V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

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

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.0310382\text{E-}011$$

$$V_u = 3.3940726\text{E-}031$$

$$d = 0.8 D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

$$\text{From } (11.5.4.8), \text{ACI } 318-14: V_s = V_{s1} + V_{s2} = 308425.138$$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$$A_v = \frac{1}{2} A_{\text{stirrup}} = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

$$V_{s1} \text{ is multiplied by } \text{Col1} = 1.00$$

$$s/d = 0.25$$

$V_{s2} = 0.00$ is calculated for core, with:

$$A_v = \frac{1}{2} A_{\text{stirrup}} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

$$V_{s2} \text{ is multiplied by } \text{Col2} = 0.00$$

$$s/d = 1.04167$$

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

$$\text{From } (11-11), \text{ACI } 440: V_s + V_f \leq 457232.663$$

$$b_w d = \frac{1}{4} d^2 = 125663.706$$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 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
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.36696
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = 300.00$
 No FRP Wrapping

Stepwise Properties

At local axis: 2
 EDGE -A-
 Shear Force, $V_a = 1.5777218E-030$
 EDGE -B-
 Shear Force, $V_b = -1.5777218E-030$
 BOTH EDGES
 Axial Force, $F = -7389.214$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 3053.628$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1017.876$
 -Compression: $As_{l,com} = 1017.876$
 -Middle: $As_{l,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6646E+008$
 $\mu_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6646E+008$
 $\mu_{u2+} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $\mu_{u2-} = 1.6646E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u

Mu = 1.6646E+008

= 0.76794487

' = 0.68333426

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{external} = 100.00$

$n = 12.00$

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 1.6646E+008

= 0.76794487

' = 0.68333426

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $f_c = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 1.6646E+008$

$\phi = 0.76794487$
 $\phi' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $\phi_{cc} = \phi_c \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $\phi_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of ϕ_y : $\phi_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$
 $l_b/l_d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= \phi_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $\phi_y = 781.25$
Mean concrete strength: $\phi_c' = (\phi_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + \phi_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $\phi_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$
 $V_{r1} = V_{CoI}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{CoI}$
 $V_{CoI} = 524225.731$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot \phi_y \cdot d / s$ ' is replaced by ' $V_s + \phi_y \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
Mean concrete strength: $\phi_c' = (\phi_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + \phi_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $\phi_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu = 1.6629350E-011$
 $V_u = 1.5777218E-030$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7389.214$
 $A_g = 196349.541$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$
 $V_{s1} = 308425.138$ is calculated for jacket, with:

$$A_v = \sqrt{2} A_{\text{stirrup}} = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.25$$

Vs2 = 0.00 is calculated for core, with:

$$A_v = \sqrt{2} A_{\text{stirrup}} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.04167$$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$$b_w d = \sqrt{2} d^2 / 4 = 125663.706$$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_n l V_{\text{Col}0}$

$$V_{\text{Col}0} = 524225.731$$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d / s$ ' is replaced by ' $V_s + f V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} A_{\text{jacket}} + f_c'_{\text{core}} A_{\text{core}}) / A_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1.6629350E-011$$

$$V_u = 1.5777218E-030$$

$$d = 0.8 D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

Vs1 = 308425.138 is calculated for jacket, with:

$$A_v = \sqrt{2} A_{\text{stirrup}} = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.25$$

Vs2 = 0.00 is calculated for core, with:

$$A_v = \sqrt{2} A_{\text{stirrup}} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.04167$$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$$b_w d = \sqrt{2} d^2 / 4 = 125663.706$$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00

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:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 1.4708285E-010$

Shear Force, $V_2 = 7406.71$

Shear Force, $V_3 = 5.9790306E-013$

Axial Force, $F = -7386.251$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{c,com} = 1017.876$

-Middle: $As_{mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_L = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03285837$

$u = y + p = 0.03285837$

- Calculation of y -

 $y = (M_y * L_s / 3) / E_{eff} = 0.0032404$ ((4.29), Biskinis Phd))

$M_y = 1.5355E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.3694E+013$

factor = 0.30

$A_g = 196349.541$

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 30.00$

$N = 7386.251$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

 $M_y = \min(M_{y,ten}, M_{y,com}) = 1.5355E+008$

$y = 4.4159560E-006$

$M_{y,ten} (8c) = 1.5355E+008$

$\sigma_{ten}(7c) = 64.86205$
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
 $\sigma_{com}(7d) = 65.27568$
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) $\epsilon_y = \text{Min}(\epsilon_y, 1.25 \cdot \epsilon_y \cdot (l_b/l_d)^{2/3}) = 0.003125$
 $\epsilon_{co} = 0.002$
 $\alpha_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7386.251$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $= \text{Min}(, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.324$
with $f_c = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.16240769$
 $l_b = 300.00$
 $l_d = 1847.203$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \sqrt{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

- Calculation of ρ_p -

From table 10-9: $\rho_p = 0.02961797$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$
shear control ratio $V_y E / V_{col} E = 0.21168476$
 $d = d_{external} = 0.00$
 $s = s_{external} = 0.00$
 $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00323428$
jacket: $s_1 = A_{v1} \cdot (D_{c1} / 2) / (s_1 \cdot A_g) = 0.0027646$
 $A_{v1} = 78.53982$, is the area of stirrup
 $D_{c1} = D_{ext} - 2 \cdot \text{cover} - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s_1 = 100.00$
core: $s_2 = A_{v2} \cdot (D_{c2} / 2) / (s_2 \cdot A_g) = 0.00046968$
 $A_{v2} = 50.26548$, is the area of stirrup
 $D_{c2} = D_{int} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s_2 = 250.00$
The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution
where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation f_s of jacket is used.
 $N_{UD} = 7386.251$
 $A_g = 196349.541$
 $f_{cE} = (f_{c,jacket} \cdot \text{Area}_{jacket} + f_{c,core} \cdot \text{Area}_{core}) / \text{section_area} = 30.00$
 $f_{yE} = (f_{y,ext_Long_Reinf} \cdot \text{Area}_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot \text{Area}_{int_Long_Reinf}) / \text{Area_Tot_Long_Rein} =$

2.1219958E-314

$f_{ytE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 625.00$

$p_l = Area_Tot_Long_Rein / (A_g) = 0.015552$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

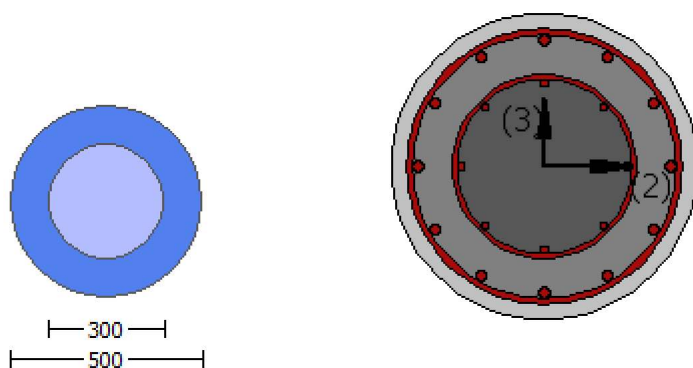
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $= 1.00$

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

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$
 New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of γ for displacement ductility demand,
 the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
 Deformation-Controlled Action (Table C7-1, ASCE 41-17).
 Jacket
 New material: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material: Steel Strength, $f_s = f_{sm} = 625.00$
 Existing Column
 New material: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material: Steel Strength, $f_s = f_{sm} = 625.00$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 1.6470537E-009$
 Shear Force, $V_a = -5.9790306E-013$
 EDGE -B-
 Bending Moment, $M_b = 1.4708285E-010$
 Shear Force, $V_b = 5.9790306E-013$
 BOTH EDGES
 Axial Force, $F = -7386.251$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 3053.628$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1017.876$
 -Compression: $As_{c,com} = 1017.876$
 -Middle: $As_{c,mid} = 1017.876$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 423209.102$
 V_n ((10.3), ASCE 41-17) = $k_n l \cdot V_{CoI} = 423209.102$
 $V_{CoI} = 423209.102$
 $k_n l = 1.00$
 displacement_ductility_demand = 0.00

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c \cdot \text{jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 20.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 1.4708285E-010$
 $V_u = 5.9790306E-013$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7386.251$

$A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 246740.11$
 $V_{s1} = 246740.11$ is calculated for jacket, with:
 $A_v = \frac{1}{2} A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} A_{stirrup} = 78956.835$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 373328.906$
 $b_w d = \frac{1}{4} d^2 = 125663.706$

displacement ductility demand is calculated as $\frac{1}{y}$

- Calculation of $\frac{1}{y}$ for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $= 8.3963180E-021$
 $y = (M_y * L_s / 3) / E_{eff} = 0.0032404 ((4.29), Biskinis Phd)$
 $M_y = 1.5355E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) $= 1500.00$
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.3694E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$
 $N = 7386.251$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 7.8978E+013$

Calculation of Yielding Moment M_y

Calculation of $\frac{1}{y}$ and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \min(M_{y,ten}, M_{y,com}) = 1.5355E+008$
 $y = 4.4159560E-006$
 $M_{y,ten} (8c) = 1.5355E+008$
 $_{ten} (7c) = 64.86205$
 error of function (7c) $= 0.00290247$
 $M_{y,com} (8d) = 7.1091E+008$
 $_{com} (7d) = 65.27568$
 error of function (7d) $= -0.00596425$
 with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.003125$
 $e_{co} = 0.002$
 $apl = 0.35 ((9a) \text{ in Biskinis and Fardis for no FRP Wrap})$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7386.251$
 $A_c = 196349.541$
 ((10.1), ASCE 41-17) $= \min(, 1.25 * (l_b / l_d)^{2/3}) = 0.324$
 with $f_c = 30.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_d, \min = 0.16240769$
 $l_b = 300.00$

ld = 1847.203

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

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

= 1

db = 18.00

Mean strength value of all re-bars: fy = 625.00

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 4.11234

Atr = $\pi/2 \cdot \text{Area of external stirrup} = 123.3701$

s = s_external = 100.00

n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

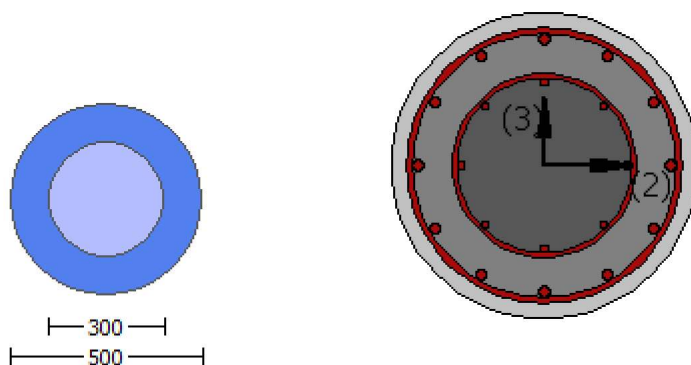
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
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
Jacket
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
Existing Column
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

External Diameter, $D = 500.00$
Internal Diameter, $D = 300.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.36696
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 3.3940726E-031$
EDGE -B-
Shear Force, $V_b = -3.3940726E-031$
BOTH EDGES
Axial Force, $F = -7389.214$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1017.876$
-Compression: $A_{st,com} = 1017.876$
-Middle: $A_{st,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6646E+008$
 $\mu_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6646E+008$
 $\mu_{u2+} = 1.6646E+008$, 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

Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.10389295

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

= 0.76794487
' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TDY: fcc = fc* c = 41.00884
conf. factor c = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 250.5135
lb/d = 0.12992616
d1 = 44.00
R = 250.00

$$v = 0.00125393$$

$$N = 7389.214$$

$$Ac = 196349.541$$

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.10389295$$

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616

lb = 300.00

ld = 2309.004

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

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

db = 18.00

Mean strength value of all re-bars: fy = 781.25

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 4.11234

Atr = /2 * Area of external stirrup = 123.3701

s = s_external = 100.00

n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 1.6646E+008

$$= 0.76794487$$

$$' = 0.68333426$$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: fcc = fc' c = 41.00884

conf. factor c = 1.36696

fc = 30.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 250.5135

lb/d = 0.12992616

d1 = 44.00

R = 250.00

v = 0.00125393

N = 7389.214

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.10389295$$

Calculation of ratio lb/d

Lap Length: lb/d = 0.12992616

lb = 300.00

ld = 2309.004

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

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

db = 18.00

Mean strength value of all re-bars: fy = 781.25

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

$cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} * \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f_c' * c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 250.5135$
 $l_b/d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $= * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} * \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$
 $V_{r1} = V_{CoI} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{CoI0}$
 $V_{CoI0} = 524225.731$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0310382E-011$$

$$V_u = 3.3940726E-031$$

$$d = 0.8 \cdot D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 308425.138$$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$$A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$$s/d = 0.25$$

$V_{s2} = 0.00$ is calculated for core, with:

$$A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$$s/d = 1.04167$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 457232.663$$

$$b_w \cdot d = \frac{1}{4} \cdot d^2 = 125663.706$$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$$V_{r2} = V_{\text{Col}} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{\text{Col0}}$$

$$V_{\text{Col0}} = 524225.731$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

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

$$\text{Mean concrete strength: } f'_c = (f'_c \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3$$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0310382E-011$$

$$V_u = 3.3940726E-031$$

$$d = 0.8 \cdot D = 400.00$$

$$N_u = 7389.214$$

$$A_g = 196349.541$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 308425.138$$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$$A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 625.00$$

$$s = 100.00$$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$$s/d = 0.25$$

$V_{s2} = 0.00$ is calculated for core, with:

$$A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 78956.835$$

$$f_y = 625.00$$

$$s = 250.00$$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$$s/d = 1.04167$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 457232.663$$

$$b_w \cdot d = \frac{1}{4} \cdot d^2 = 125663.706$$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, $= 1.00$

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

Consequently:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section $= 1.36696$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.5777218E-030$

EDGE -B-

Shear Force, $V_b = -1.5777218E-030$

BOTH EDGES

Axial Force, $F = -7389.214$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{l,com} = 1017.876$

-Middle: $As_{l,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.21168476$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 110970.60$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6646E+008$

$M_{u1+} = 1.6646E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction

which is defined for the static loading combination

$\mu_{1-} = 1.6646 \times 10^8$, 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

$\mu_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.6646 \times 10^8$

$\mu_{2+} = 1.6646 \times 10^8$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{2-} = 1.6646 \times 10^8$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646 \times 10^8$

$\phi = 0.76794487$

$\lambda = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TB DY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$

$f_c = 30.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 250.5135$

$l_b/l_d = 0.12992616$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00125393$

$N = 7389.214$

$A_c = 196349.541$

$\phi \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.12992616$

$l_b = 300.00$

$l_d = 2309.004$

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

l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$\phi = 1$

$\phi_b = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$\phi_b = 25.00$

$K_{tr} = 4.11234$

$A_{tr} = \phi_b / 2 \cdot \text{Area of external stirrup} = 123.3701$

$s = s_{\text{external}} = 100.00$

$n = 12.00$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646 \times 10^8$

$\phi = 0.76794487$

$\lambda = 0.68333426$

error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TB DY: $f_{cc} = f_c' \cdot c = 41.00884$

conf. factor $c = 1.36696$
 $fc = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 250.5135$
 $lb/ld = 0.12992616$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 0.10389295$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.12992616$
 $lb = 300.00$
 $ld = 2309.004$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = /2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of Mu_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
 $Mu = 1.6646E+008$

$= 0.76794487$
 $' = 0.68333426$
 error of function (3.68), Biskinis Phd = 48475.514
 From 5A.2, TBDY: $fcc = fc \cdot c = 41.00884$
 conf. factor $c = 1.36696$
 $fc = 30.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 250.5135$
 $lb/ld = 0.12992616$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}) = 0.10389295$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.12992616$
 $lb = 300.00$
 $ld = 2309.004$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$

Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 1.6646E+008$

$\mu_u = 0.76794487$
 $\mu_u = 0.68333426$
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: $f_{cc} = f'_c \cdot c = 41.00884$
conf. factor $c = 1.36696$
 $f_c = 30.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 250.5135$
 $l_b/d = 0.12992616$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7389.214$
 $A_c = 196349.541$
 $\mu_u = \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.10389295$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.12992616$
 $l_b = 300.00$
 $l_d = 2309.004$
Calculation of l_b , min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $\mu_u = 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \frac{1}{2} \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{external} = 100.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 524225.731$

Calculation of Shear Strength at edge 1, $V_{r1} = 524225.731$
 $V_{r1} = V_{CoI} ((10.3), ASCE 41-17) = knl \cdot V_{CoIO}$
 $V_{CoIO} = 524225.731$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$V_u = 1.5777218E-030$

$d = 0.8 \cdot D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \pi/2 \cdot A_{\text{stirrup}} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \pi/2 \cdot A_{\text{stirrup}} = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$b_w \cdot d = \pi \cdot d \cdot d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 524225.731$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{ColO}}$

$V_{\text{ColO}} = 524225.731$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.6629350E-011$

$V_u = 1.5777218E-030$

$d = 0.8 \cdot D = 400.00$

$N_u = 7389.214$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 308425.138$

$V_{s1} = 308425.138$ is calculated for jacket, with:

$A_v = \pi/2 \cdot A_{\text{stirrup}} = 123370.055$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.25$

$V_{s2} = 0.00$ is calculated for core, with:

$A_v = \pi/2 \cdot A_{\text{stirrup}} = 78956.835$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 1.04167$

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

From (11-11), ACI 440: $V_s + V_f \leq 457232.663$

$b_w \cdot d = \pi \cdot d \cdot d / 4 = 125663.706$

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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:

Jacket

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 0.07915355$

Shear Force, $V_2 = 7406.71$

Shear Force, $V_3 = 5.9790306E-013$

Axial Force, $F = -7386.251$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1017.876$

-Compression: $A_{sl,com} = 1017.876$

-Middle: $A_{sl,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_L = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03026605$

$u = \gamma + p = 0.03026605$

- Calculation of γ -

$\gamma = (M \cdot L_s / 3) / E_{eff} = 0.00064808$ ((4.29), Biskinis Phd))

$M_y = 1.5355E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.3694E+013$

factor = 0.30
 $A_g = 196349.541$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$
 $N = 7386.251$
 $E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 7.8978 \text{E}+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y_{\text{ten}}}, M_{y_{\text{com}}}) = 1.5355 \text{E}+008$
 $y = 4.4159560 \text{E}-006$
 $M_{y_{\text{ten}}} (8c) = 1.5355 \text{E}+008$
 $\phi_{y_{\text{ten}}} (7c) = 64.86205$
error of function (7c) = 0.00290247
 $M_{y_{\text{com}}} (8d) = 7.1091 \text{E}+008$
 $\phi_{y_{\text{com}}} (7d) = 65.27568$
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) $\phi_y = \text{Min}(\phi_y, 1.25 \cdot \phi_y \cdot (l_b/l_d)^{2/3}) = 0.003125$
 $\phi_{co} = 0.002$
 $\phi_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00125393$
 $N = 7386.251$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $\phi_y = \text{Min}(\phi_y, 1.25 \cdot \phi_y \cdot (l_b/l_d)^{2/3}) = 0.324$
with $f_c = 30.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,\text{min}} = 0.16240769$
 $l_b = 300.00$
 $l_d = 1847.203$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,\text{min}}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 4.11234$
 $A_{tr} = \pi/2 \cdot \text{Area of external stirrup} = 123.3701$
 $s = s_{\text{external}} = 100.00$
 $n = 12.00$

- Calculation of ρ_p -

From table 10-9: $\rho_p = 0.02961797$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$
- shear control ratio $V_y E / V_{co} I_{OE} = 0.21168476$
- $d = d_{\text{external}} = 0.00$
- $s = s_{\text{external}} = 0.00$
- $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00323428$
- jacket: $s_1 = A_{v1} \cdot (\pi \cdot D_{c1} / 2) / (s_1 \cdot A_g) = 0.0027646$
- $A_{v1} = 78.53982$, is the area of stirrup
- $D_{c1} = D_{\text{ext}} - 2 \cdot \text{cover} - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading

(shear) direction

$$s1 = 100.00$$

core: $s2 = Av2 * (Dc2/2) / (s2 * Ag) = 0.00046968$

$Av2 = 50.26548$, is the area of stirrup

$Dc2 = D_{int} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear)

direction

$$s2 = 250.00$$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$NUD = 7386.251$$

$$Ag = 196349.541$$

$$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section_area = 30.00$$

$$f_{yLE} = (f_{y,ext_Long_Reinf} * Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} * Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 2.1219958E-314$$

$$f_{yTE} = (f_{y,ext_Trans_Reinf} * Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} * Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} = 625.00$$

$$\rho_l = Area_{Tot_Long_Rein} / (Ag) = 0.015552$$

$$f_{cE} = 30.00$$

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)
