

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

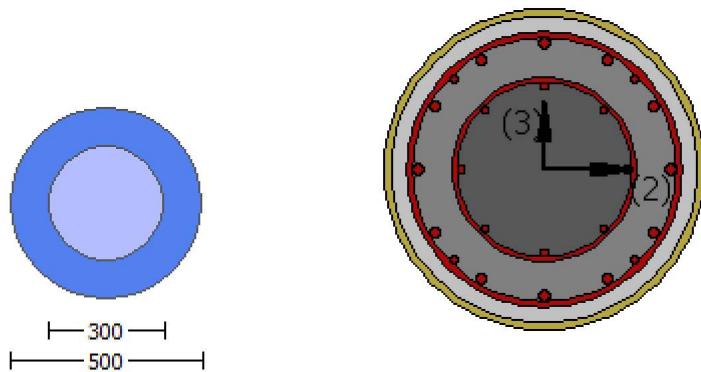
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
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, $f_c = f_{cm} = 33.00$
New material: Steel Strength, $f_s = f_{sm} = 555.56$
Existing Column
New material: Concrete Strength, $f_c = f_{cm} = 33.00$
New material: Steel Strength, $f_s = f_{sm} = 555.56$

External Diameter, $D = 500.00$
Internal Diameter, $D = 300.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, $t = 1.00$
Tensile Strength, $f_{fu} = 840.00$
Tensile Modulus, $E_f = 82000.00$
Elongation, $e_{fu} = 0.009$
Number of directions, $NoDir = 1$
Fiber orientations, $bi: 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -2.1459E+007$
Shear Force, $V_a = -7151.182$
EDGE -B-
Bending Moment, $M_b = 0.12668604$
Shear Force, $V_b = 7151.182$
BOTH EDGES
Axial Force, $F = -7422.996$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1498.54$
-Compression: $As_c = 2007.478$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1168.672$
-Compression: $As_{c,com} = 1168.672$
-Middle: $As_{mid} = 1168.672$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 * V_n = 515960.724$
 V_n ((10.3), ASCE 41-17) = $knI * V_{ColO} = 515960.724$
 $V_{Col} = 515960.724$
 $knI = 1.00$

displacement_ductility_demand = 0.02290074

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 2.1459 \times 10^7$

$V_u = 7151.182$

$d = 0.8 \cdot D = 400.00$

$N_u = 7422.996$

$A_g = 196349.541$

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 $\text{Col1} = 1.00$

$s/d = 0.25$

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

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

$f_y = 500.00$

$s = 250.00$

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

$s/d = 1.04167$

V_f ((11-3)-(11.4), ACI 440) = 308320.00

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,

where a is the angle of the crack direction (see KANEPE).

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

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

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

f_{fe} ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 417394.406$

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

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

- Calculation of $\frac{1}{y}$ for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation $\theta = 0.00023666$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.01033423$ ((4.29), Biskinis Phd))

$M_y = 2.5674 \times 10^8$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.733

From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 2.4850 \times 10^{13}$

factor = 0.30

$A_g = 196349.541$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$

$N = 7422.996$

$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 8.2833 \times 10^{13}$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.5674\text{E}+008$

$y = 6.5559618\text{E}-006$

$M_{y_ten} (8c) = 2.5674\text{E}+008$

$y_{ten} (7c) = 63.43072$

error of function (7c) = 0.00011855

$M_{y_com} (8d) = 8.5656\text{E}+008$

$y_{com} (7d) = 64.71642$

error of function (7d) = -0.00696579

with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 \cdot e_y \cdot (l_b/l_d)^{2/3}) = 0.0027778$

$e_{co} = 0.002$

$a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101864$

$N = 7422.996$

$A_c = 196349.541$

((10.1), ASCE 41-17) $= \text{Min}(, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.26729306$

with f_c^* ((12.3), ACI 440) = 37.11312

$f_c = 33.00$

$f_l = 1.312$

$k = 1$

Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.00$

e_{fe} ((12.5) and (12.7)) = 0.004

$f_u = 0.009$

$E_f = 82000.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

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

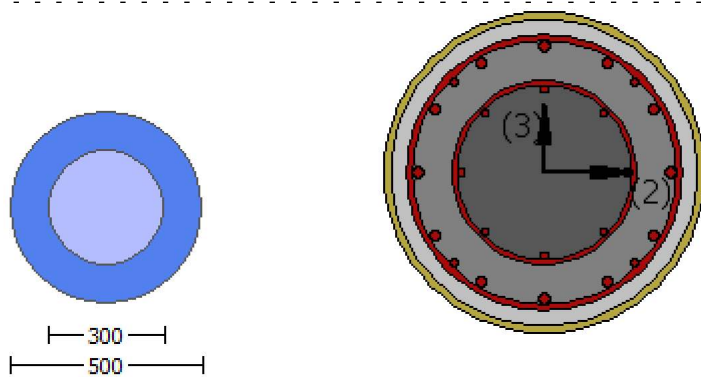
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_u)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

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Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

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External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $efu = 0.009$

Number of directions, $NoDir = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.8218291\text{E-}031$

EDGE -B-

Shear Force, $V_b = 3.8218291\text{E-}031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1168.672$

-Compression: $A_{sc,com} = 1168.672$

-Middle: $A_{st,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 2.7881\text{E+}008$

$\mu_{1+} = 2.7881\text{E+}008$, 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

$\mu_{1-} = 2.7881\text{E+}008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 2.7881\text{E+}008$

$\mu_{2+} = 2.7881\text{E+}008$, 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

$\mu_{2-} = 2.7881\text{E+}008$, 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 μ_{1+}

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

$\mu_u = 2.7881\text{E+}008$

$= 0.83775804$

$' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$A_c = 196349.541$

$= \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874

conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

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

$V_{\text{Col}0} = 705818.864$

$k_{nl} = 1$ (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: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.4329951\text{E-}011$

$\mu_u = 3.8218291\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f ((11-3)-(11.4), \text{ACI 440}) = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} ((11-5), \text{ACI 440}) = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 705818.864$$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M / Vd = 2.00$$

$$\mu_u = 1.4329951E-011$$

$$\nu_u = 3.8218291E-031$$

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

$$N_u = 7425.858$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.25$$

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

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

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.04167$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$$

$f = 0.95$, for fully-wrapped sections

$w_f / s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

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

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

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{Dir} = 1.00$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 470.00$$

$$f_{fe} \text{ ((11-5), ACI 440)} = 328.00$$

$$E_f = 82000.00$$

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

$$\text{with } f_u = 0.009$$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $ef_u = 0.009$

Number of directions, $NoDir = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -7.8886091E-031$

EDGE -B-

Shear Force, $V_b = 7.8886091E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1168.672$

-Compression: $As_{c,com} = 1168.672$

-Middle: $As_{l,mid} = 1168.672$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$

with

$$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.7881\text{E}+008$$

$M_{u1+} = 2.7881\text{E}+008$, 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

$M_{u1-} = 2.7881\text{E}+008$, 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

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.7881\text{E}+008$$

$M_{u2+} = 2.7881\text{E}+008$, 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

$M_{u2-} = 2.7881\text{E}+008$, 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
 $M_u = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$$f_c = 33.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$$f_c = 33.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

$$lb/d = 0.30$$

$$d1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$Ac = 196349.541$$

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

$$lb/d = 0.30$$

$$d1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$Ac = 196349.541$$

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705818.864

Calculation of Shear Strength at edge 1, Vr1 = 705818.864

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

$$VColO = 705818.864$$

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.9925299\text{E-}011$

$\nu_u = 7.8886091\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

$A_v = A_s / 2 = 123370.055$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

$A_v = A_s / 2 = 78956.835$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

V_f ((11-3)-(11.4), ACI 440) = 308320.00

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,

where a is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

f_{fe} ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

$b_w \cdot d = A_s \cdot d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$V_{r2} = V_{\text{Col}}((10.3), \text{ASCE 41-17}) = \text{knl} \cdot V_{\text{Col0}}$

$V_{\text{Col0}} = 705818.864$

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.9925299\text{E-}011$

$\nu_u = 7.8886091\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

$A_v = A_s / 2 = 123370.055$

$f_y = 555.56$

$s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe} ((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \sqrt{V_s + V_f} \cdot d / 4 = 125663.706$

 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: 2
 Integration Section: (a)
 Section Type: rcjcs

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon

Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $\epsilon_{fu} = 0.009$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i = 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 1.0896809E-009$
 Shear Force, $V_2 = -7151.182$
 Shear Force, $V_3 = -3.1520820E-013$
 Axial Force, $F = -7422.996$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 1498.54$
 -Compression: $A_{sl,c} = 2007.478$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1168.672$
 -Compression: $A_{sl,com} = 1168.672$
 -Middle: $A_{sl,mid} = 1168.672$
 Mean Diameter of Tension Reinforcement, $D_bL = 16.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = 1.0^*$ $\phi_u = 0.00516585$
 $\phi_u = \phi_y + \phi_p = 0.00516585$

- Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00516585$ ((4.29), Biskinis Phd))
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7422.996$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y,ten}, M_{y,com}) = 2.5674E+008$
 $\phi_y = 6.5559618E-006$
 $M_{y,ten} (8c) = 2.5674E+008$
 $\phi_{y,ten} (7c) = 63.43072$
 error of function (7c) = 0.00011855
 $M_{y,com} (8d) = 8.5656E+008$
 $\phi_{y,com} (7d) = 64.71642$
 error of function (7d) = -0.00696579
 with ((10.1), ASCE 41-17) $\phi_y = \min(\phi_y, 1.25 * \phi_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $\phi_{eco} = 0.002$
 $\phi_{apl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101864$
 $N = 7422.996$
 $A_c = 196349.541$

$((10.1), \text{ASCE 41-17}) = \text{Min}(, 1.25 * (lb/ld)^{2/3}) = 0.26729306$
 with $f_c^* ((12.3), \text{ACI 440}) = 37.11312$
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \cos(b1) = 1.00$
 $e_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

- Calculation of p -

From table 10-9: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.26334747$

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

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

$t = s1 + s2 + 2 * t_f / bw * (f_{fe} / f_s) = 0.00795744$

jacket: $s1 = A_{v1} * (Dc1 / 2) / (s1 * A_g) = 0.0027646$

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

$Dc1 = D_{\text{ext}} - 2 * \text{cover} - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s1 = 100.00$

core: $s2 = A_{v2} * (Dc2 / 2) / (s2 * A_g) = 0.00046968$

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

$Dc2 = D_{\text{int}} - \text{Internal Hoop Diameter} = 292.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s2 = 250.00$

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

where $f = 2 * t_f / bw$ 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.

$N_{UD} = 7422.996$

$A_g = 196349.541$

$f_{cE} = (f_{c_jacket} * \text{Area_jacket} + f_{c_core} * \text{Area_core}) / \text{section_area} = 33.00$

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

$f_{yTE} = (f_{y_ext_Trans_Reinf} * \text{Area_ext_Trans_Reinf} + f_{y_int_Trans_Reinf} * \text{Area_int_Trans_Reinf}) / \text{Area_Tot_Trans_Rein} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.017856$

$f_{cE} = 33.00$

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

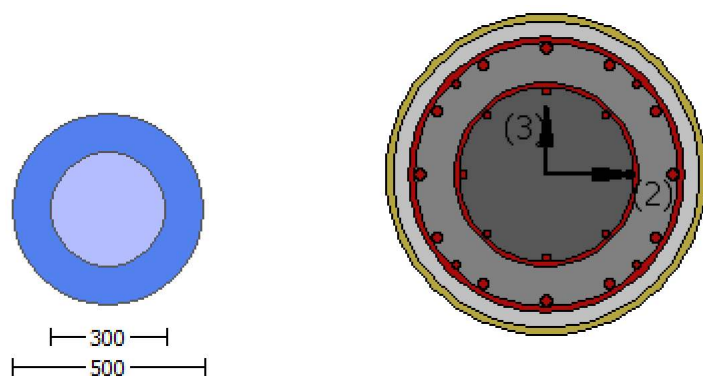
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $e_{fu} = 0.009$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 1.0896809E-009$
 Shear Force, $V_a = -3.1520820E-013$
 EDGE -B-
 Bending Moment, $M_b = -1.4375693E-010$
 Shear Force, $V_b = 3.1520820E-013$
 BOTH EDGES
 Axial Force, $F = -7422.996$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 1498.54$
 -Compression: $A_{sl,c} = 2007.478$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1168.672$
 -Compression: $A_{sl,com} = 1168.672$
 -Middle: $A_{sl,mid} = 1168.672$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 614527.043$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 614527.043$
 $V_{Col} = 614527.043$
 $knl = 1.00$
 $displacement_ductility_demand = 0.00$

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: $f'_c = (f'_c_jacket \cdot Area_jacket + f'_c_core \cdot Area_core) / Area_section = 25.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.0896809E-009$
 $\nu_u = 3.1520820E-013$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7422.996$
 $A_g = 196349.541$
 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 $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = /2 \cdot A_stirrup = 78956.835$
 $f_y = 500.00$
 $s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 417394.406$
 $bw * d = \rho * d^2 / 4 = 125663.706$

displacement_ductility_demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 1.3497213E-020$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00516585$ ((4.29), Biskinis Phd)
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 2.4850E+013$
 $\text{factor} = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$
 $N = 7422.996$
 $E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_{\text{ten}}}, M_{y_{\text{com}}}) = 2.5674E+008$
 $y = 6.5559618E-006$
 $M_{y_{\text{ten}}} (8c) = 2.5674E+008$
 $\delta_{\text{ten}} (7c) = 63.43072$
 error of function (7c) = 0.00011855
 $M_{y_{\text{com}}} (8d) = 8.5656E+008$
 $\delta_{\text{com}} (7d) = 64.71642$
 error of function (7d) = -0.00696579
 with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00101864$
 $N = 7422.996$
 $A_c = 196349.541$
 ((10.1), ASCE 41-17) $\rho = \text{Min}(\rho, 1.25 * \rho * (I_b / I_d)^{2/3}) = 0.26729306$
 with f'_c ((12.3), ACI 440) = 37.11312
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
 Effective FRP thickness, $tf = NL * t * \cos(b1) = 1.00$
 $e_{fe}((12.5) \text{ and } (12.7)) = 0.004$

$f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

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

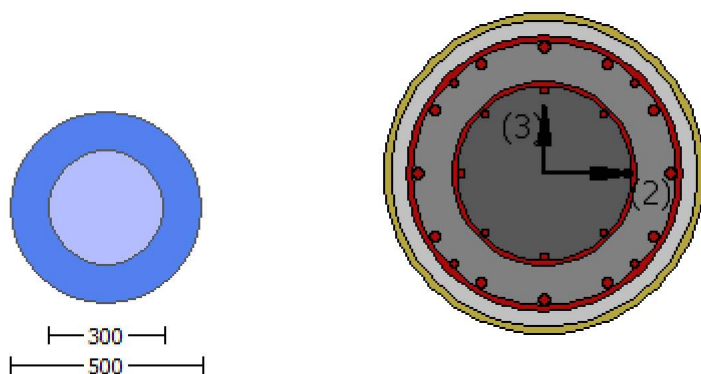
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.51481
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $\epsilon_{fu} = 0.009$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -3.8218291E-031$
 EDGE -B-
 Shear Force, $V_b = 3.8218291E-031$
 BOTH EDGES
 Axial Force, $F = -7425.858$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3506.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1168.672$
 -Compression: $A_{sl,com} = 1168.672$
 -Middle: $A_{sl,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.7881E+008$
 $\mu_{u1+} = 2.7881E+008$, 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
 $\mu_{u1-} = 2.7881E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.7881E+008$

Mu2+ = 2.7881E+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- = 2.7881E+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 = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TBDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TBDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705818.864

Calculation of Shear Strength at edge 1, Vr1 = 705818.864

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 705818.864

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).

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

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.4329951E-011$

$\nu_u = 3.8218291E-031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f ((11-3)-(11.4), \text{ACI 440}) = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot \alpha) \sin \alpha$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

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

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

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_f = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} ((11-5), \text{ACI 440}) = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

$b_w \cdot d = \sqrt{d} \cdot d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE 41-17}) = k_{nl} \cdot V_{\text{Col0}}$

$V_{\text{Col0}} = 705818.864$

$k_{nl} = 1$ (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).

$\mu_u = 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.4329951E-011$

$\nu_u = 3.8218291E-031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), \text{ACI } 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L * t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI } 440) = 328.00$
 $E_f = 82000.00$
 $f_{e1} = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w * d = \rho * d^2 / 4 = 125663.706$

 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.51481
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou, \min} = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -7.8886091E-031$

EDGE -B-

Shear Force, $V_b = 7.8886091E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1168.672$

-Compression: $A_{sl,com} = 1168.672$

-Middle: $A_{sl,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.7881E+008$

$\mu_{u1+} = 2.7881E+008$, 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

$\mu_{u1-} = 2.7881E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.7881E+008$

$\mu_{u2+} = 2.7881E+008$, 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

$\mu_{u2-} = 2.7881E+008$, 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

$\mu_u = 2.7881E+008$

$\phi = 0.83775804$

$\phi' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$$N = 7425.858$$

$$Ac = 196349.541$$

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$

$$\text{conf. factor } c = 1.51481$$

$$f_c = 33.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$

$$V_{Col0} = 705818.864$$

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

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/V_d = 2.00$$

$$Mu = 1.9925299E-011$$

$$Vu = 7.8886091E-031$$

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

$$Nu = 7425.858$$

$$Ag = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.25$$

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

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

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.04167$$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$

$$f = 0.95, \text{ for fully-wrapped sections}$$

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{V_s \cdot d}{4} = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{Col0}$
 $V_{Col0} = 705818.864$
 $k_n l = 1$ (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).

$\lambda = 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c \cdot \text{jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M / V_d = 2.00$
 $\mu_u = 1.9925299 \text{E-}011$
 $V_u = 7.8886091 \text{E-}031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7425.858$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \frac{V_{s1}}{2 \cdot A_{\text{stirrup}}} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{V_{s2}}{2 \cdot A_{\text{stirrup}}} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f / s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{V_s \cdot d}{4} = 125663.706$

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: (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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $ε_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = -2.1459E+007$

Shear Force, $V_2 = -7151.182$

Shear Force, $V_3 = -3.1520820E-013$

Axial Force, $F = -7422.996$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1498.54$

-Compression: $As_c = 2007.478$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1168.672$

-Compression: $As_{l,com} = 1168.672$

-Middle: $As_{l,mid} = 1168.672$

Mean Diameter of Tension Reinforcement, $Db_L = 16.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.01033423$

$$u = y + p = 0.01033423$$

- Calculation of y -

$$y = (My * L_s / 3) / E_{eff} = 0.01033423 \text{ ((4.29), Biskinis Phd)}$$

$$My = 2.5674E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3000.733$$

$$\text{From table 10.5, ASCE 41-17: } E_{eff} = \text{factor} * E_c * I_g = 2.4850E+013$$

$$\text{factor} = 0.30$$

$$A_g = 196349.541$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$$

$$N = 7422.996$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 8.2833E+013$$

Calculation of Yielding Moment M_y

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

$$M_y = \text{Min}(M_{y_{\text{ten}}}, M_{y_{\text{com}}}) = 2.5674E+008$$

$$y = 6.5559618E-006$$

$$M_{y_{\text{ten}}} (8c) = 2.5674E+008$$

$$y_{\text{ten}} (7c) = 63.43072$$

$$\text{error of function (7c)} = 0.00011855$$

$$M_{y_{\text{com}}} (8d) = 8.5656E+008$$

$$y_{\text{com}} (7d) = 64.71642$$

$$\text{error of function (7d)} = -0.00696579$$

$$\text{with ((10.1), ASCE 41-17) } e_y = \text{Min}(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$$

$$e_{co} = 0.002$$

$$a_{pl} = 0.45 \text{ ((9c) in Biskinis and Fardis for FRP Wrap)}$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101864$$

$$N = 7422.996$$

$$A_c = 196349.541$$

$$\text{((10.1), ASCE 41-17) } = \text{Min}(, 1.25 * (I_b / I_d)^{2/3}) = 0.26729306$$

$$\text{with } f_c' \text{ ((12.3), ACI 440) } = 37.11312$$

$$f_c = 33.00$$

$$f_l = 1.312$$

$$k = 1$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.00$$

$$e_{fe} \text{ ((12.5) and (12.7)) } = 0.004$$

$$f_u = 0.009$$

$$E_f = 82000.00$$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.00$

with:

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

$$\text{shear control ratio } V_y E / V_{co} I_{OE} = 0.26334747$$

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

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

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00795744$$

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

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

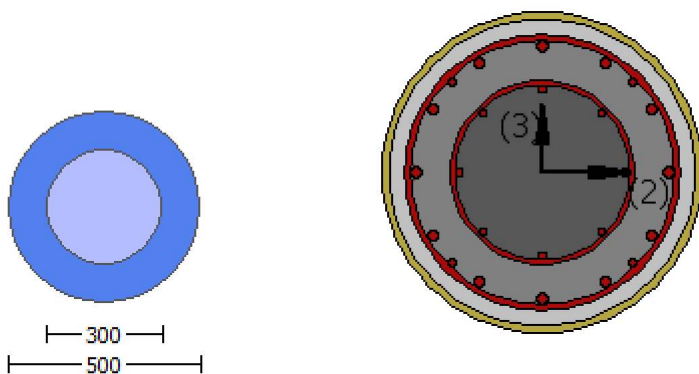
$$D_{c1} = D_{\text{ext}} - 2 * \text{cover} - \text{External Hoop Diameter} = 440.00, \text{ is the total Length of all stirrups parallel to loading (shear) direction}$$

$s1 = 100.00$
 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.
 $NUD = 7422.996$
 $Ag = 196349.541$
 $f_{cE} = (f_{c_jacket} * Area_jacket + f_{c_core} * Area_core) / section_area = 33.00$
 $f_{yIE} = (f_{y_ext_Long_Reinf} * Area_ext_Long_Reinf + f_{y_int_Long_Reinf} * Area_int_Long_Reinf) / Area_Tot_Long_Rein = 2.1219958E-314$
 $f_{yTE} = (f_{y_ext_Trans_Reinf} * Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} * Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 555.56$
 $\rho_l = Area_Tot_Long_Rein / (Ag) = 0.017856$
 $f_{cE} = 33.00$

 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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -2.1459E+007$

Shear Force, $V_a = -7151.182$

EDGE -B-

Bending Moment, $M_b = 0.12668604$

Shear Force, $V_b = 7151.182$

BOTH EDGES

Axial Force, $F = -7422.996$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1168.672$

-Compression: $A_{sl,com} = 1168.672$

-Middle: $A_{sl,mid} = 1168.672$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 614527.043$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 614527.043$

$V_{CoI} = 614527.043$

$k_n = 1.00$

$displacement_ductility_demand = 0.12535865$

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: $f'_c = (f'_c_jacket \cdot Area_jacket + f'_c_core \cdot Area_core) / Area_section = 25.00$, but $f'_c^{0.5} \leq 8.3$ MPa ((22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.12668604$

$V_u = 7151.182$

$d = 0.8 \cdot D = 400.00$

$N_u = 7422.996$

$A_g = 196349.541$

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) = 308320.00

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In ((11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

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

orientation 1: $a_1 = b_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

f_{fe} ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

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

with $f_u = 0.009$

From ((11-11), ACI 440: $V_s + V_f \leq 417394.406$

$b_w \cdot d = \sqrt{4} \cdot d^2 / 4 = 125663.706$

$displacement_ductility_demand$ is calculated as Δ / y

- Calculation of Δ / y for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta = 0.00012952$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00103317$ ((4.29), Biskinis Phd))

$M_y = 2.5674E+008$

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

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7422.996$
 $E_c * I_g = E_{c_jacket} * I_{g_jacket} + E_{c_core} * I_{g_core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.5674E+008$
 $\gamma = 6.5559618E-006$
 $M_{y_ten} (8c) = 2.5674E+008$
 $\gamma_{ten} (7c) = 63.43072$
error of function (7c) = 0.00011855
 $M_{y_com} (8d) = 8.5656E+008$
 $\gamma_{com} (7d) = 64.71642$
error of function (7d) = -0.00696579
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $\alpha_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101864$
 $N = 7422.996$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $= \min(, 1.25 * * (I_b / I_d)^{2/3}) = 0.26729306$
with f_c^* ((12.3), ACI 440) = 37.11312
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.00$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

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

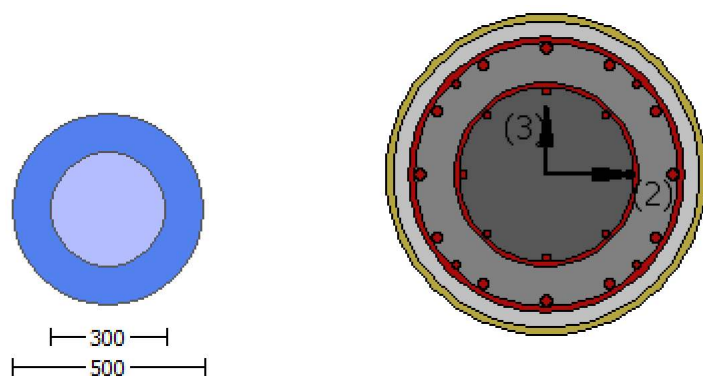
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.8218291E-031$

EDGE -B-

Shear Force, $V_b = 3.8218291E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1168.672$

-Compression: $A_{sl,com} = 1168.672$

-Middle: $A_{sl,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.7881E+008$

$\mu_{u1+} = 2.7881E+008$, 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

$\mu_{u1-} = 2.7881E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.7881E+008$

$\mu_{u2+} = 2.7881E+008$, 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

$\mu_{u2-} = 2.7881E+008$, 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

$\mu_u = 2.7881E+008$

$\phi = 0.83775804$

$\phi' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$$N = 7425.858$$

$$Ac = 196349.541$$

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$

conf. factor $c = 1.51481$

$$f_c = 33.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{Col0}$

$$V_{Col0} = 705818.864$$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\text{Mu} = 1.4329951\text{E-}011$$

$$\text{Vu} = 3.8218291\text{E-}031$$

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

$$N_u = 7425.858$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

$$A_v = \cdot /2 \cdot A_{\text{stirup}} = 123370.055$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.25$$

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

$$A_v = \cdot /2 \cdot A_{\text{stirup}} = 78956.835$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.04167$$

V_f ((11-3)-(11.4), ACI 440) = 308320.00

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{A_s \cdot d}{4} = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{Col0}$
 $V_{Col0} = 705818.864$
 $k_n l = 1$ (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).

$\lambda = 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c \cdot \text{jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.4329951E-011$
 $\nu_u = 3.8218291E-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7425.858$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \frac{A_s}{2} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{A_s}{2} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{A_s \cdot d}{4} = 125663.706$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -7.8886091E-031$

EDGE -B-

Shear Force, $V_b = 7.8886091E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3506.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 1168.672$
-Compression: $A_{s,com} = 1168.672$
-Middle: $A_{s,mid} = 1168.672$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.26334747$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 2.7881E+008$
 $M_{u1+} = 2.7881E+008$, 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
 $M_{u1-} = 2.7881E+008$, 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
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 2.7881E+008$
 $M_{u2+} = 2.7881E+008$, 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
 $M_{u2-} = 2.7881E+008$, 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 M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.7881E+008$

 $\phi = 0.83775804$
 $\phi' = 0.74468049$
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 49.98874$
conf. factor $c = 1.51481$
 $f_c = 33.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
 $= \phi \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.7881E+008$

 $\phi = 0.83775804$
 $\phi' = 0.74468049$
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 49.98874$
conf. factor $c = 1.51481$
 $f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$Ac = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

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

$\mu = 2.7881\text{E}+008$

$= 0.83775804$

$' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$Ac = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2-}

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

$\mu = 2.7881\text{E}+008$

$= 0.83775804$

$' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$Ac = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{ColO}$

$V_{ColO} = 705818.864$

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

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

$= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/V_d = 2.00$

$\mu_u = 1.9925299E-011$

$\nu_u = 7.8886091E-031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin \alpha + \cos \alpha$ is replaced with $(\cot \alpha + \cot \alpha) \sin \alpha$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} \text{ ((11-5), ACI 440)} = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{ColO}$

$V_{ColO} = 705818.864$

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

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

$\lambda = 1$ (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.9925299\text{E-}011$
 $\nu_u = 7.8886091\text{E-}031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7425.858$
 $A_g = 196349.541$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), \text{ACI } 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot_a) \sin \alpha$ which is more a generalised expression,
where α is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\alpha, \theta)$, is implemented for every different fiber orientation α_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI } 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.009$
From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \lambda \cdot d^2 / 4 = 125663.706$

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, $\lambda = 1.00$
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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $\epsilon_{fu} = 0.009$
 Number of directions, $N_{Dir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = -1.4375693E-010$
 Shear Force, $V_2 = 7151.182$
 Shear Force, $V_3 = 3.1520820E-013$
 Axial Force, $F = -7422.996$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3506.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1168.672$
 -Compression: $A_{sc,com} = 1168.672$
 -Middle: $A_{st,mid} = 1168.672$
 Mean Diameter of Tension Reinforcement, $D_{bL} = 15.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00516585$
 $u = y + p = 0.00516585$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00516585$ ((4.29), Biskinis Phd))
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7422.996$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y,ten}, M_{y,com}) = 2.5674E+008$
 $y = 6.5559618E-006$
 $M_{y,ten} (8c) = 2.5674E+008$

```

_ten (7c) = 63.43072
error of function (7c) = 0.00011855
My_com (8d) = 8.5656E+008
_com (7d) = 64.71642
error of function (7d) = -0.00696579
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101864
N = 7422.996
Ac = 196349.541
((10.1), ASCE 41-17) = Min( , 1.25* *(lb/ld)^ 2/3) = 0.26729306
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
k = 1
Effective FRP thickness, tf = NL*t*cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
fu = 0.009
Ef = 82000.00

```

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of p -

From table 10-9: $p = 0.00$

with:

- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio $VyE/VCoIE = 0.26334747$
 $d = d_{external} = 0.00$
 $s = s_{external} = 0.00$
 $t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00795744$
jacket: $s1 = Av1*(Dc1/2)/(s1*Ag) = 0.0027646$
 $Av1 = 78.53982$, is the area of stirrup
 $Dc1 = Dext - 2*cover - External\ Hoop\ Diameter = 440.00$, 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
 $Dc2 = Dint - Internal\ Hoop\ Diameter = 292.00$, 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 = 7422.996
Ag = 196349.541
fcE = (fc_jacket*Area_jacket+ fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+ fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein =
21219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+ fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein =
555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.017856
fcE = 33.00

```

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

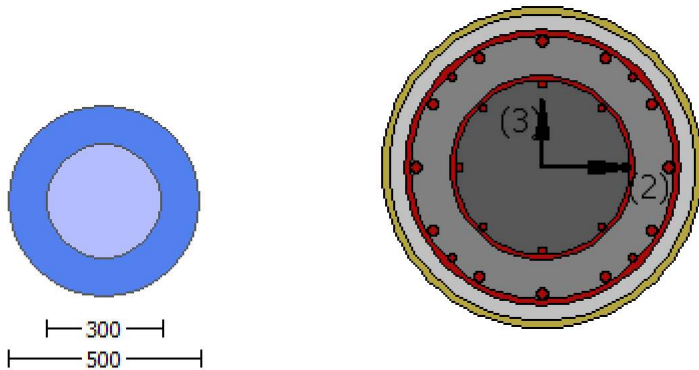
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity 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, $\gamma = 1.00$

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$


```

New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
#####
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment, Ma = 1.0896809E-009
Shear Force, Va = -3.1520820E-013
EDGE -B-
Bending Moment, Mb = -1.4375693E-010
Shear Force, Vb = 3.1520820E-013
BOTH EDGES
Axial Force, F = -7422.996
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension: Ast = 0.00
  -Compression: Asc = 3506.017
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension: Ast,ten = 1168.672
  -Compression: Asc,com = 1168.672
  -Middle: Asc,mid = 1168.672
Mean Diameter of Tension Reinforcement, DbL,ten = 15.60
-----
-----

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 614527.043
Vn ((10.3), ASCE 41-17) = knl*VCoI0 = 614527.043
VCoI = 614527.043
knl = 1.00
displacement_ductility_demand = 0.00
-----

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 = 25.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4375693E-010
Vu = 3.1520820E-013
d = 0.8*D = 400.00
Nu = 7422.996

```

$A_g = 196349.541$
 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 $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $a = 45^\circ$ and $a = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $a = b1 + 90^\circ = 90.00$
 $V_f = \min(|V_f(45, 1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L * t / N_{oDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe} ((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 417394.406$
 $b_w * d = \frac{1}{4} * d * d = 125663.706$

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 $\theta = 7.8224733E-021$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00516585$ ((4.29), Biskinis Phd))
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7422.996$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y,ten}, M_{y,com}) = 2.5674E+008$
 $y = 6.5559618E-006$
 $M_{y,ten} (8c) = 2.5674E+008$
 $\delta_{ten} (7c) = 63.43072$
 error of function (7c) = 0.00011855
 $M_{y,com} (8d) = 8.5656E+008$
 $\delta_{com} (7d) = 64.71642$
 error of function (7d) = -0.00696579
 with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $\alpha_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)

$d1 = 44.00$
 $R = 250.00$
 $v = 0.00101864$
 $N = 7422.996$
 $Ac = 196349.541$
 $((10.1), ASCE 41-17) = \text{Min}(, 1.25 * (lb/d)^{2/3}) = 0.26729306$
 with $fc^* ((12.3), ACI 440) = 37.11312$
 $fc = 33.00$
 $fl = 1.312$
 $k = 1$
 Effective FRP thickness, $tf = NL * t * \text{Cos}(b1) = 1.00$
 $efe ((12.5) \text{ and } (12.7)) = 0.004$
 $fu = 0.009$
 $Ef = 82000.00$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

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

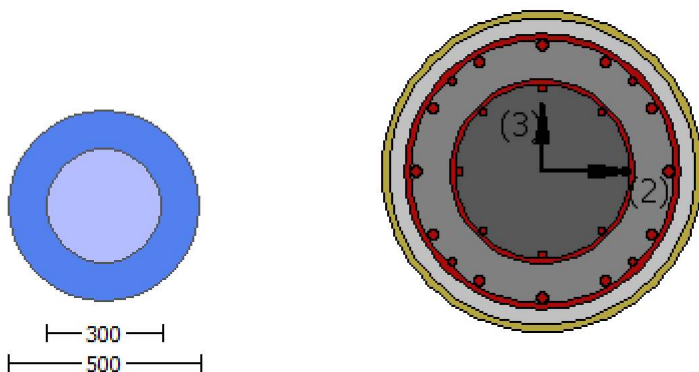
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.8218291E-031$

EDGE -B-

Shear Force, $V_b = 3.8218291E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1168.672$

-Compression: $As_{l,com} = 1168.672$

-Middle: $As_{l,mid} = 1168.672$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 2.7881\text{E}+008$

$\mu_{1+} = 2.7881\text{E}+008$, 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

$\mu_{1-} = 2.7881\text{E}+008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 2.7881\text{E}+008$

$\mu_{2+} = 2.7881\text{E}+008$, 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

$\mu_{2-} = 2.7881\text{E}+008$, 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 μ_{1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.7881\text{E}+008$

$\phi = 0.83775804$

$\phi' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TB DY: $f_{cc} = f_c^* \quad c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$A_c = 196349.541$

$= \phi \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.7881\text{E}+008$

$\phi = 0.83775804$

$\phi' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TB DY: $f_{cc} = f_c^* \quad c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$A_c = 196349.541$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$A_c = 196349.541$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$A_c = 196349.541$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 705818.864$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.4329951E-011$

$\nu_u = 3.8218291E-031$

$d = 0.8 * D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f / s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,

where a is the angle of the crack direction (see KANEPE).

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

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

$V_f = \min(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = N_L * t / N_{Dir} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} \text{ ((11-5), ACI 440)} = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 705818.864$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.4329951E-011$

$\nu_u = 3.8218291E-031$

$d = 0.8 * D = 400.00$

$N_u = 7425.858$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \frac{1}{2} A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{1}{2} A_{stirrup} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $a = 45^\circ$ and $a = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $a_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $tf_1 = NL * t / NoDir = 1.00$
 $df_v = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe} ((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $bw * d = \frac{1}{4} * d * d = 125663.706$

 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, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$

#####

External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, $f_{fu} = 840.00$
Tensile Modulus, $E_f = 82000.00$
Elongation, $efu = 0.009$
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -7.8886091E-031$
EDGE -B-
Shear Force, $V_b = 7.8886091E-031$
BOTH EDGES
Axial Force, F = -7425.858
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3506.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1168.672$
-Compression: $As_{l,com} = 1168.672$
-Middle: $As_{l,mid} = 1168.672$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.26334747$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 2.7881E+008$
 $Mu_{1+} = 2.7881E+008$, 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
 $Mu_{1-} = 2.7881E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 2.7881E+008$
 $Mu_{2+} = 2.7881E+008$, 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
 $Mu_{2-} = 2.7881E+008$, 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
 $Mu = 2.7881E+008$

= 0.83775804
 ' = 0.74468049
 error of function (3.68), Biskinis Phd = 48760.493
 From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 49.98874$
 conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

= 0.83775804
 ' = 0.74468049
 error of function (3.68), Biskinis Phd = 48760.493
 From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 49.98874$
 conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $Ac = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_2 +

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

= 0.83775804
 ' = 0.74468049
 error of function (3.68), Biskinis Phd = 48760.493
 From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 49.98874$
 conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$

$d1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $Ac = 196349.541$
 $= *Min(1, 1.25*(lb/d)^{2/3}) = 0.18607842$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of $Mu2$ -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
 $Mu = 2.7881E+008$

$= 0.83775804$
 $' = 0.74468049$
 error of function (3.68), Biskinis Phd = 48760.493
 From 5A.2, TDY: $f_{cc} = f_c * c = 49.98874$
 conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y * Min(1, 1.25*(lb/d)^{2/3}) = 389.0139$
 $lb/d = 0.30$
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $Ac = 196349.541$
 $= *Min(1, 1.25*(lb/d)^{2/3}) = 0.18607842$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 705818.864$
 $knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 1.9925299E-011$
 $Vu = 7.8886091E-031$
 $d = 0.8 * D = 400.00$
 $Nu = 7425.858$
 $Ag = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = /2 * A_{stirrup} = 123370.055$
 $f_y = 555.56$

$s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe} ((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{V_s + V_f}{f_e} = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} \cdot V_{ColO}$
 $V_{ColO} = 705818.864$
 $k_{nl} = 1$ (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).

$\rho = 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 1.9925299E-011$
 $V_u = 7.8886091E-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7425.858$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $tf1 = NL \cdot t / NoDir = 1.00$
 $dfv = d$ (figure 11.2, ACI 440) = 470.00
 ffe ((11-5), ACI 440) = 328.00
 $Ef = 82000.00$
 $fe = 0.004$, from (11.6a), ACI 440
 with $fu = 0.009$
 From (11-11), ACI 440: $Vs + Vf \leq 479549.663$
 $bw \cdot d = \frac{1}{4} \cdot d \cdot d = 125663.706$

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: (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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b / l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $ff_u = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $ef_u = 0.009$
 Number of directions, $NoDir = 1$
 Fiber orientations, $bi: 0.00^\circ$
 Number of layers, $NL = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 0.12668604$
 Shear Force, $V2 = 7151.182$
 Shear Force, $V3 = 3.1520820E-013$
 Axial Force, $F = -7422.996$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$
 -Compression: $As_c = 3506.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1168.672$
 -Compression: $As_{c,com} = 1168.672$
 -Middle: $As_{c,mid} = 1168.672$
 Mean Diameter of Tension Reinforcement, $Db_L = 16.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00103317$
 $u = y + p = 0.00103317$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.00103317$ ((4.29), Biskinis Phd))
 $My = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7422.996$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.2833E+013$

Calculation of Yielding Moment My

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

$My = \min(My_{ten}, My_{com}) = 2.5674E+008$
 $y = 6.5559618E-006$
 $My_{ten} (8c) = 2.5674E+008$
 $_{ten} (7c) = 63.43072$
 error of function (7c) = 0.00011855
 $My_{com} (8d) = 8.5656E+008$
 $_{com} (7d) = 64.71642$
 error of function (7d) = -0.00696579
 with ((10.1), ASCE 41-17) $ey = \min(ey, 1.25 * ey * (I_b / I_d)^{2/3}) = 0.0027778$
 $eco = 0.002$
 $apl = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00101864$
 $N = 7422.996$
 $A_c = 196349.541$
 ((10.1), ASCE 41-17) $= \min(, 1.25 * (I_b / I_d)^{2/3}) = 0.26729306$
 with fc^* ((12.3), ACI 440) = 37.11312
 $fc = 33.00$
 $f_l = 1.312$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \cos(b1) = 1.00$
 efe ((12.5) and (12.7)) = 0.004
 $fu = 0.009$
 $E_f = 82000.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- 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 $V_{yE}/V_{ColOE} = 0.26334747$

$d = d_{external} = 0.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00795744$

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

$D_{c1} = D_{ext} - 2 \cdot cover - \text{External Hoop Diameter} = 440.00$, 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 $2 \cdot t_f/bw \cdot (f_{fe}/f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f/bw$ 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.

$NUD = 7422.996$

$A_g = 196349.541$

$f_{cE} = (f_{c,jacket} \cdot \text{Area}_{jacket} + f_{c,core} \cdot \text{Area}_{core})/\text{section_area} = 33.00$

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

$f_{yIE} = (f_{y,ext_Trans_Reinf} \cdot \text{Area}_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot \text{Area}_{int_Trans_Reinf})/\text{Area}_{Tot_Trans_Rein} = 555.56$

$\rho_l = \text{Area}_{Tot_Long_Rein}/(A_g) = 0.017856$

$f_{cE} = 33.00$

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

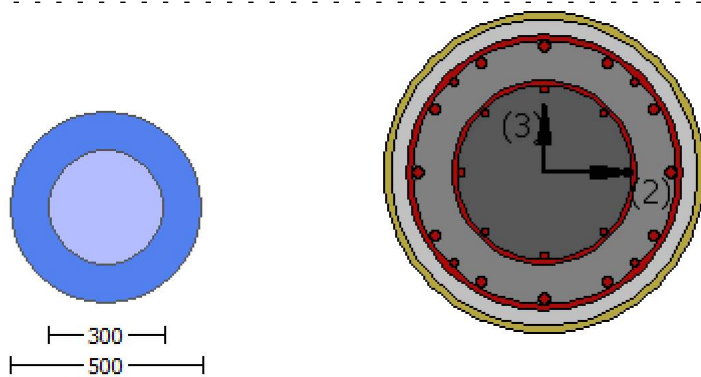
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: 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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 Existing Column
 New material: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $e_{fu} = 0.009$
 Number of directions, $NoDir = 1$
 Fiber orientations, $bi: 0.00^\circ$
 Number of layers, $NL = 1$

Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-

Bending Moment, Ma = -1.3587E+007

Shear Force, Va = -4527.977

EDGE -B-

Bending Moment, Mb = 0.08021491

Shear Force, Vb = 4527.977

BOTH EDGES

Axial Force, F = -7424.046

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 3506.017

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1168.672

-Compression: Asl,com = 1168.672

-Middle: Asl,mid = 1168.672

Mean Diameter of Tension Reinforcement, DbL,ten = 16.28571

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 515960.829

Vn ((10.3), ASCE 41-17) = knl*VCol0 = 515960.829

VCol = 515960.829

knl = 1.00

displacement_ductility_demand = 0.01450025

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: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 1.3587E+007

Vu = 4527.977

d = 0.8*D = 400.00

Nu = 7424.046

Ag = 196349.541

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11

Vs1 = 246740.11 is calculated for jacket, with:

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

fy = 500.00

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 = 500.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.04167

Vf ((11-3)-(11.4), ACI 440) = 308320.00

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = \alpha_1 + 90^\circ = 90.00$

$Vf = \min(|Vf(45, \alpha_1)|, |Vf(-45, \alpha_1)|)$, with:

total thickness per orientation, tf1 = NL*t/NoDir = 1.00

dfv = d (figure 11.2, ACI 440) = 470.00

$f_{fe} ((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 417394.406$
 $b_w \cdot d = \frac{d^2}{4} = 125663.706$

displacement ductility demand is calculated as $\frac{V}{y}$

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

From analysis, chord rotation $\theta = 0.00014985$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01033424$ ((4.29), Biskinis Phd))
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.733
 From table 10.5, ASCE 41-17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 33.00$
 $N = 7424.046$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.5674E+008$
 $y = 6.5559635E-006$
 $M_{y_ten} (8c) = 2.5674E+008$
 $\frac{V}{y} (7c) = 63.43074$
 error of function (7c) = 0.00011855
 $M_{y_com} (8d) = 8.5656E+008$
 $\frac{V}{y} (7d) = 64.71643$
 error of function (7d) = -0.00696577
 with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 \cdot e_y \cdot (I_b/I_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101879$
 $N = 7424.046$
 $A_c = 196349.541$
 ((10.1), ASCE 41-17) $\phi = \min(\phi, 1.25 \cdot \phi \cdot (I_b/I_d)^{2/3}) = 0.26729306$
 with f'_c ((12.3), ACI 440) = 37.11312
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
 Effective FRP thickness, $t_f = N \cdot L \cdot \cos(b_1) = 1.00$
 e_f ((12.5) and (12.7)) = 0.004
 $f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

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

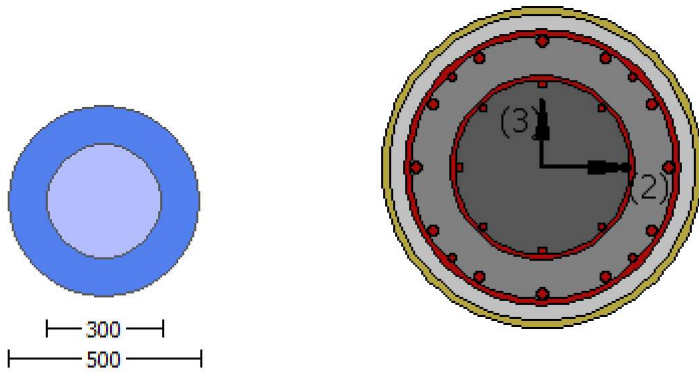
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min}$ = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, f_{fu} = 840.00
Tensile Modulus, E_f = 82000.00
Elongation, $ε_{fu}$ = 0.009
Number of directions, NoDir = 1
Fiber orientations, b_i : 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, V_a = -3.8218291E-031
EDGE -B-
Shear Force, V_b = 3.8218291E-031
BOTH EDGES
Axial Force, F = -7425.858
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t}$ = 0.00
-Compression: $A_{sl,c}$ = 3506.017
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten}$ = 1168.672
-Compression: $A_{sl,com}$ = 1168.672
-Middle: $A_{sl,mid}$ = 1168.672

Calculation of Shear Capacity ratio , V_e/V_r = 0.26334747
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with
$M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 2.7881\text{E}+008$
$\mu_{u1+} = 2.7881\text{E}+008$, 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
$\mu_{u1-} = 2.7881\text{E}+008$, 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
$M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 2.7881\text{E}+008$
$\mu_{u2+} = 2.7881\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
$\mu_{u2-} = 2.7881\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
$\mu_u = 2.7881\text{E}+008$

= 0.83775804
 ' = 0.74468049
 error of function (3.68), Biskinis Phd = 48760.493
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$
 conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

= 0.83775804
 ' = 0.74468049
 error of function (3.68), Biskinis Phd = 48760.493
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$
 conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_2 +

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

= 0.83775804
 ' = 0.74468049
 error of function (3.68), Biskinis Phd = 48760.493
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$
 conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$

$$\begin{aligned}
 R &= 250.00 \\
 v &= 0.00101313 \\
 N &= 7425.858 \\
 A_c &= 196349.541 \\
 &= * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 0.18607842
 \end{aligned}$$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881 \text{E}+008$

$$\begin{aligned}
 &= 0.83775804 \\
 ' &= 0.74468049 \\
 \text{error of function (3.68), Biskinis Phd} &= 48760.493 \\
 \text{From 5A.2, TBDY: } f_{cc} &= f_c' \cdot c = 49.98874 \\
 \text{conf. factor } c &= 1.51481 \\
 f_c &= 33.00 \\
 \text{From 10.3.5, ASCE 41-17, Final value of } f_y &: f_y * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 389.0139 \\
 l_b / d &= 0.30 \\
 d_1 &= 44.00 \\
 R &= 250.00 \\
 v &= 0.00101313 \\
 N &= 7425.858 \\
 A_c &= 196349.541 \\
 &= * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 0.18607842
 \end{aligned}$$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Co10}$

$V_{Co10} = 705818.864$

$k_{nl} = 1$ (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).

$$\begin{aligned}
 &= 1 \text{ (normal-weight concrete)} \\
 \text{Mean concrete strength: } f_c' &= (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \\
 \text{MPa (22.5.3.1, ACI 318-14)} & \\
 M / V_d &= 2.00 \\
 \mu_u &= 1.4329951 \text{E}-011 \\
 V_u &= 3.8218291 \text{E}-031 \\
 d &= 0.8 * D = 400.00 \\
 N_u &= 7425.858 \\
 A_g &= 196349.541 \\
 \text{From (11.5.4.8), ACI 318-14: } V_s &= V_{s1} + V_{s2} = 274157.871 \\
 V_{s1} &= 274157.871 \text{ is calculated for jacket, with:} \\
 A_v &= /2 * A_{\text{stirrup}} = 123370.055 \\
 f_y &= 555.56 \\
 s &= 100.00
 \end{aligned}$$

Vs1 is multiplied by Col1 = 1.00
s/d = 0.25

Vs2 = 0.00 is calculated for core, with:

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

$f_y = 555.56$

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.04167

Vf ((11-3)-(11.4), ACI 440) = 308320.00

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
where α is the angle of the crack direction (see KANEPE).

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

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

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

total thickness per orientation, $t_{f1} = NL * t / \text{NoDir} = 1.00$

dfv = d (figure 11.2, ACI 440) = 470.00

ffe ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$V_{r2} = V_{Col} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 705818.864$

$k_{nl} = 1$ (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 Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_{jacket} * \text{Area}_{jacket} + f'_c_{core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.4329951E-011$

$V_u = 3.8218291E-031$

d = 0.8 * D = 400.00

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

Vs1 = 274157.871 is calculated for jacket, with:

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

$f_y = 555.56$

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.25

Vs2 = 0.00 is calculated for core, with:

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

$f_y = 555.56$

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.04167

Vf ((11-3)-(11.4), ACI 440) = 308320.00

f = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
where α is the angle of the crack direction (see KANEPE).

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

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

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

total thickness per orientation, $t_{f1} = NL * t / \text{NoDir} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 f_{fe} ((11-5), ACI 440) = 328.00
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{V_s \cdot d}{4} = 125663.706$

 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.51481
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $efu = 0.009$
 Number of directions, $NoDir = 1$
 Fiber orientations, $bi: 0.00^\circ$
 Number of layers, $NL = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -7.8886091\text{E-}031$

EDGE -B-

Shear Force, $V_b = 7.8886091\text{E-}031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1168.672$

-Compression: $A_{sc,com} = 1168.672$

-Middle: $A_{st,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 2.7881\text{E}+008$

$\mu_{1+} = 2.7881\text{E}+008$, 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

$\mu_{1-} = 2.7881\text{E}+008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 2.7881\text{E}+008$

$\mu_{2+} = 2.7881\text{E}+008$, 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

$\mu_{2-} = 2.7881\text{E}+008$, 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 μ_{1+}

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

$\mu_u = 2.7881\text{E}+008$

$= 0.83775804$

$' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$A_c = 196349.541$

$= \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874

conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

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

$V_{\text{Col}0} = 705818.864$

$k_{nl} = 1$ (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: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.9925299\text{E-}011$

$\nu_u = 7.8886091\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f ((11-3)-(11.4), \text{ACI 440}) = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} ((11-5), \text{ACI 440}) = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 705818.864$$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M / Vd = 2.00$$

$$\mu_u = 1.9925299E-011$$

$$\nu_u = 7.8886091E-031$$

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

$$N_u = 7425.858$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.25$$

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

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

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.04167$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$$

$f = 0.95$, for fully-wrapped sections

$w_f / s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

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

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

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{Dir} = 1.00$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 470.00$$

$$f_{fe} \text{ ((11-5), ACI 440)} = 328.00$$

$$E_f = 82000.00$$

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

$$\text{with } f_u = 0.009$$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

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: 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 6.9521932E-010$

Shear Force, $V_2 = -4527.977$

Shear Force, $V_3 = -1.9958314E-013$

Axial Force, $F = -7424.046$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1168.672$

-Compression: $As_{l,com} = 1168.672$

-Middle: $As_{l,mid} = 1168.672$

Mean Diameter of Tension Reinforcement, $Db_L = 16.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03516586$

$u = y + p = 0.03516586$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00516586$ ((4.29), Biskinis Phd)

$M_y = 2.5674E+008$

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

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$

$factor = 0.30$

$A_g = 196349.541$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 7424.046$

$$E_c I_g = E_{c_jacket} I_{g_jacket} + E_{c_core} I_{g_core} = 8.2833E+013$$

Calculation of Yielding Moment M_y

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

$$M_y = \min(M_{y_ten}, M_{y_com}) = 2.5674E+008$$

$$\rho_y = 6.5559635E-006$$

$$M_{y_ten} (8c) = 2.5674E+008$$

$$\rho_{y_ten} (7c) = 63.43074$$

$$\text{error of function (7c)} = 0.00011855$$

$$M_{y_com} (8d) = 8.5656E+008$$

$$\rho_{y_com} (7d) = 64.71643$$

$$\text{error of function (7d)} = -0.00696577$$

$$\text{with } ((10.1), \text{ASCE 41-17}) \rho_y = \min(\rho_y, 1.25 \rho_y (I_b/I_d)^{2/3}) = 0.0027778$$

$$\rho_{eco} = 0.002$$

$$\rho_{apl} = 0.45 ((9c) \text{ in Biskinis and Fardis for FRP Wrap})$$

$$d1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101879$$

$$N = 7424.046$$

$$A_c = 196349.541$$

$$((10.1), \text{ASCE 41-17}) \rho_y = \min(\rho_y, 1.25 \rho_y (I_b/I_d)^{2/3}) = 0.26729306$$

$$\text{with } f_c^* ((12.3), \text{ACI 440}) = 37.11312$$

$$f_c = 33.00$$

$$f_l = 1.312$$

$$k = 1$$

$$\text{Effective FRP thickness, } t_f = N L^* t \cos(b1) = 1.00$$

$$e_{fe} ((12.5) \text{ and } (12.7)) = 0.004$$

$$f_u = 0.009$$

$$E_f = 82000.00$$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

- Calculation of ρ_p -

From table 10-9: $\rho_p = 0.03$

with:

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

$$\text{shear control ratio } V_y E / V_{col} O E = 0.26334747$$

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

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

$$t = s1 + s2 + 2 t_f / b_w (f_{fe} / f_s) = 0.00795744$$

jacket: $s1 = A_{v1} (D_{c1} / 2) / (s1 A_g) = 0.0027646$

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

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

$$s1 = 100.00$$

core: $s2 = A_{v2} (D_{c2} / 2) / (s2 A_g) = 0.00046968$

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

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

$$s2 = 250.00$$

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.

$$N U D = 7424.046$$

$$A_g = 196349.541$$

$$f_{cE} = (f_{c_jacket} \cdot \text{Area}_{\text{jacket}} + f_{c_core} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 33.00$$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 2.1219958E-314$
 $f_{yE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 555.56$
 $p_l = Area_Tot_Long_Rein / (A_g) = 0.017856$
 $f_{cE} = 33.00$

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

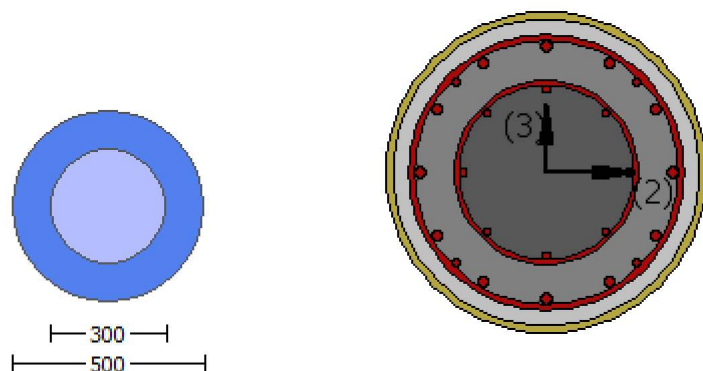
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: 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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

```

Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
#####
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$ 
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength,  $f_{fu} = 840.00$ 
Tensile Modulus,  $E_f = 82000.00$ 
Elongation,  $\epsilon_{fu} = 0.009$ 
Number of directions, NoDir = 1
Fiber orientations,  $b_i: 0.00^\circ$ 
Number of layers, NL = 1
Radius of rounding corners, R = 40.00
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment,  $M_a = 6.9521932E-010$ 
Shear Force,  $V_a = -1.9958314E-013$ 
EDGE -B-
Bending Moment,  $M_b = -9.6280367E-011$ 
Shear Force,  $V_b = 1.9958314E-013$ 
BOTH EDGES
Axial Force, F = -7424.046
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{sl,t} = 0.00$ 
-Compression:  $A_{sl,c} = 3506.017$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{sl,ten} = 1168.672$ 
-Compression:  $A_{sl,com} = 1168.672$ 
-Middle:  $A_{sl,mid} = 1168.672$ 
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.00$ 
-----
-----

New component: From table 7-7, ASCE 41_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 614527.251$ 
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{CoIO} = 614527.251$ 
 $V_{CoI} = 614527.251$ 
 $knl = 1.00$ 
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: $f'_c = (f'_c \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 25.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.9521932E-010$

$V_u = 1.9958314E-013$

$d = 0.8 \cdot D = 400.00$

$N_u = 7424.046$

$A_g = 196349.541$

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:

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

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 500.00$

$s = 250.00$

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

$s/d = 1.04167$

V_f ((11-3)-(11.4), ACI 440) = 308320.00

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

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

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

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

f_{fe} ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

$f_{fe} = 0.004$, from (11.6a), ACI 440

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 417394.406$

$b_w \cdot d = \sqrt{2} \cdot d^2 / 4 = 125663.706$

displacement_ductility_demand is calculated as δ / y

- Calculation of δ / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 8.5461487E-021$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00516586$ ((4.29), Biskinis Phd))

$M_y = 2.5674E+008$

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

From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 2.4850E+013$

factor = 0.30

$A_g = 196349.541$

Mean concrete strength: $f'_c = (f'_c \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$

$N = 7424.046$

$E_c \cdot I_g = E_c \cdot \text{Area}_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c \cdot \text{Area}_{\text{core}} \cdot I_{g_{\text{core}}} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.5674\text{E}+008$
 $y = 6.5559635\text{E}-006$
 $M_{y_ten} (8c) = 2.5674\text{E}+008$
 $_{ten} (7c) = 63.43074$
error of function (7c) = 0.00011855
 $M_{y_com} (8d) = 8.5656\text{E}+008$
 $_{com} (7d) = 64.71643$
error of function (7d) = -0.00696577
with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101879$
 $N = 7424.046$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $= \text{Min}(, 1.25 * (l_b / l_d)^{2/3}) = 0.26729306$
with f_c^* ((12.3), ACI 440) = 37.11312
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.00$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

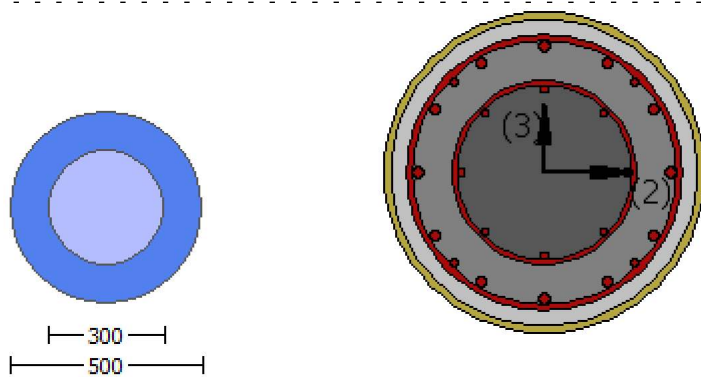
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $efu = 0.009$

Number of directions, $NoDir = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.8218291\text{E-}031$

EDGE -B-

Shear Force, $V_b = 3.8218291\text{E-}031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1168.672$

-Compression: $A_{sc,com} = 1168.672$

-Middle: $A_{st,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 2.7881\text{E+}008$

$\mu_{1+} = 2.7881\text{E+}008$, 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

$\mu_{1-} = 2.7881\text{E+}008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 2.7881\text{E+}008$

$\mu_{2+} = 2.7881\text{E+}008$, 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

$\mu_{2-} = 2.7881\text{E+}008$, 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 μ_{1+}

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

$\mu_u = 2.7881\text{E+}008$

$= 0.83775804$

$' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$A_c = 196349.541$

$= \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874

conf. factor $c = 1.51481$
 $f_c = 33.00$
 From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

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

$V_{\text{Col}0} = 705818.864$

$k_{nl} = 1$ (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: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.4329951\text{E-}011$

$\mu_u = 3.8218291\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f ((11-3)-(11.4), \text{ACI 440}) = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} ((11-5), \text{ACI 440}) = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

$$b_w*d = \frac{b*d}{4} = 125663.706$$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l * V_{Col0}$$

$$V_{Col0} = 705818.864$$

$k_n l = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 1.4329951E-011$$

$$V_u = 3.8218291E-031$$

$$d = 0.8 * D = 400.00$$

$$N_u = 7425.858$$

$$A_g = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.25$$

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

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

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.04167$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

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

orientation 1: $a_1 = b_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L * t / N_{Dir} = 1.00$

$$d_{fv} = d \text{ (figure 11.2, ACI 440)} = 470.00$$

$$f_{fe} \text{ ((11-5), ACI 440)} = 328.00$$

$$E_f = 82000.00$$

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

$$\text{with } f_u = 0.009$$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

$$b_w*d = \frac{b*d}{4} = 125663.706$$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $ef_u = 0.009$

Number of directions, $NoDir = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -7.8886091E-031$

EDGE -B-

Shear Force, $V_b = 7.8886091E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1168.672$

-Compression: $As_{l,com} = 1168.672$

-Middle: $As_{l,mid} = 1168.672$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$

with

$$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.7881\text{E}+008$$

$M_{u1+} = 2.7881\text{E}+008$, 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

$M_{u1-} = 2.7881\text{E}+008$, 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

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.7881\text{E}+008$$

$M_{u2+} = 2.7881\text{E}+008$, 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

$M_{u2-} = 2.7881\text{E}+008$, 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
 $M_u = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$$f_c = 33.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$$f_c = 33.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.7881\text{E}+008$

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

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

$$V_{ColO} = 705818.864$$

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.9925299\text{E-}011$

$\nu_u = 7.8886091\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

V_f ((11-3)-(11.4), ACI 440) = 308320.00

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,

where a is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

f_{fe} ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$V_{r2} = V_{\text{Col}}((10.3), \text{ASCE 41-17}) = \text{knl} \cdot V_{\text{Col0}}$

$V_{\text{Col0}} = 705818.864$

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.9925299\text{E-}011$

$\nu_u = 7.8886091\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_{stirrup} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f ((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe} ((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \sqrt{V_s + V_f} \cdot d / 4 = 125663.706$

 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: (a)
 Section Type: rcjcs

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon

Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $\epsilon_{fu} = 0.009$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i = 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = -1.3587E+007$
 Shear Force, $V_2 = -4527.977$
 Shear Force, $V_3 = -1.9958314E-013$
 Axial Force, $F = -7424.046$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3506.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1168.672$
 -Compression: $A_{sl,com} = 1168.672$
 -Middle: $A_{sl,mid} = 1168.672$
 Mean Diameter of Tension Reinforcement, $D_{bL} = 16.28571$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = 1.0^*$ $\phi_u = 0.04033424$
 $\phi_u = \phi_y + \phi_p = 0.04033424$

- Calculation of ϕ_y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01033424$ ((4.29), Biskinis Phd))
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.733
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7424.046$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y,ten}, M_{y,com}) = 2.5674E+008$
 $\phi_y = 6.5559635E-006$
 $M_{y,ten} (8c) = 2.5674E+008$
 $\phi_{y,ten} (7c) = 63.43074$
 error of function (7c) = 0.00011855
 $M_{y,com} (8d) = 8.5656E+008$
 $\phi_{y,com} (7d) = 64.71643$
 error of function (7d) = -0.00696577
 with ((10.1), ASCE 41-17) $\phi_y = \min(\phi_y, 1.25 * \phi_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $\phi_{eco} = 0.002$
 $\phi_{apl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101879$
 $N = 7424.046$
 $A_c = 196349.541$

$((10.1), ASCE\ 41-17) = \text{Min}(, 1.25 * (lb/ld)^{2/3}) = 0.26729306$
 with $f_c^* ((12.3), ACI\ 440) = 37.11312$
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.00$
 $e_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

- Calculation of p -

From table 10-9: $p = 0.03$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.26334747$

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

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

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00795744$

jacket: $s_1 = A_{v1} * (Dc_1 / 2) / (s_1 * A_g) = 0.0027646$

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

$Dc_1 = D_{\text{ext}} - 2 * \text{cover} - \text{External Hoop Diameter} = 440.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} * (Dc_2 / 2) / (s_2 * A_g) = 0.00046968$

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

$Dc_2 = D_{\text{int}} - \text{Internal Hoop Diameter} = 292.00$, 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.

$N_{UD} = 7424.046$

$A_g = 196349.541$

$f_{cE} = (f_{c_jacket} * \text{Area_jacket} + f_{c_core} * \text{Area_core}) / \text{section_area} = 33.00$

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

$f_{yTE} = (f_{y_ext_Trans_Reinf} * \text{Area_ext_Trans_Reinf} + f_{y_int_Trans_Reinf} * \text{Area_int_Trans_Reinf}) / \text{Area_Tot_Trans_Rein} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.017856$

$f_{cE} = 33.00$

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

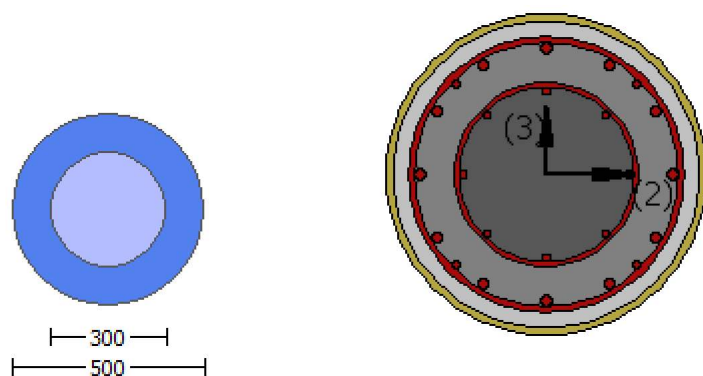
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: 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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $ε_{fu} = 0.009$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -1.3587E+007$
 Shear Force, $V_a = -4527.977$
 EDGE -B-
 Bending Moment, $M_b = 0.08021491$
 Shear Force, $V_b = 4527.977$
 BOTH EDGES
 Axial Force, $F = -7424.046$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3506.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1168.672$
 -Compression: $A_{sl,com} = 1168.672$
 -Middle: $A_{sl,mid} = 1168.672$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.28571$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 614527.251$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 614527.251$
 $V_{Col} = 614527.251$
 $knl = 1.00$
 $displacement_ductility_demand = 0.07937438$

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: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 25.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.08021491$
 $V_u = 4527.977$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7424.046$
 $A_g = 196349.541$
 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 $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 $\ln(11.3) \sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 417394.406$
 $b_w * d = \rho * d^2 / 4 = 125663.706$

displacement_ductility_demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 8.2007348E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00103317$ ((4.29), Biskinis Phd))
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41-17: $E_{eff} = \text{factor} * E_c * I_g = 2.4850E+013$
 $\text{factor} = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$
 $N = 7424.046$
 $E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_{\text{ten}}}, M_{y_{\text{com}}}) = 2.5674E+008$
 $y = 6.5559635E-006$
 $M_{y_{\text{ten}}} (8c) = 2.5674E+008$
 $\delta_{\text{ten}} (7c) = 63.43074$
 error of function (7c) = 0.00011855
 $M_{y_{\text{com}}} (8d) = 8.5656E+008$
 $\delta_{\text{com}} (7d) = 64.71643$
 error of function (7d) = -0.00696577
 with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d1 = 44.00$
 $R = 250.00$
 $v = 0.00101879$
 $N = 7424.046$
 $A_c = 196349.541$
 ((10.1), ASCE 41-17) $\rho = \text{Min}(\rho, 1.25 * \rho * (I_b / I_d)^{2/3}) = 0.26729306$
 with f'_c ((12.3), ACI 440) = 37.11312
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
 Effective FRP thickness, $tf = NL * t * \cos(b1) = 1.00$
 $e_{fe}((12.5) \text{ and } (12.7)) = 0.004$

$f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

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

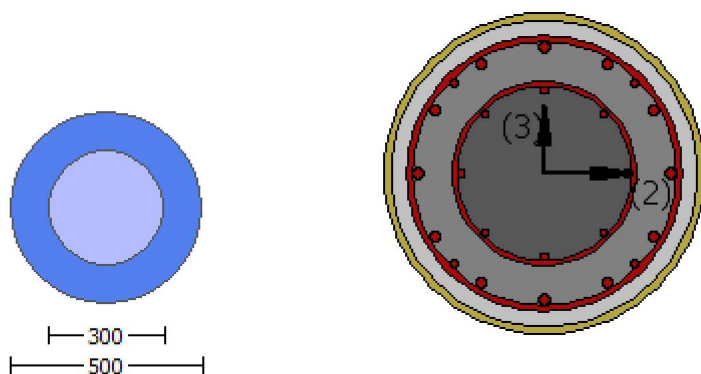
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
Existing Column
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

External Diameter, $D = 500.00$
Internal Diameter, $D = 300.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.51481
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, $t = 1.00$
Tensile Strength, $f_{fu} = 840.00$
Tensile Modulus, $E_f = 82000.00$
Elongation, $\epsilon_{fu} = 0.009$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -3.8218291E-031$
EDGE -B-
Shear Force, $V_b = 3.8218291E-031$
BOTH EDGES
Axial Force, $F = -7425.858$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 3506.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1168.672$
-Compression: $A_{sl,com} = 1168.672$
-Middle: $A_{sl,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.7881E+008$
 $\mu_{u1+} = 2.7881E+008$, 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
 $\mu_{u1-} = 2.7881E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.7881E+008$

Mu2+ = 2.7881E+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- = 2.7881E+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 = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: fcc = fc* c = 49.98874
conf. factor c = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 250.00
v = 0.00101313
N = 7425.858
Ac = 196349.541
= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705818.864

Calculation of Shear Strength at edge 1, Vr1 = 705818.864

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 705818.864

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.4329951E-011$

$\nu_u = 3.8218291E-031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f ((11-3)-(11.4), \text{ACI 440}) = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot \alpha) \sin \alpha$ which is more a generalised expression, where α is the angle of the crack direction (see KANEPE).

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

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

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

total thickness per orientation, $t_f = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} ((11-5), \text{ACI 440}) = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

$b_w \cdot d = \sqrt{d} \cdot d / 4 = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

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

$V_{\text{ColO}} = 705818.864$

$k_n l = 1$ (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).

$\mu_u = 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.4329951E-011$

$\nu_u = 3.8218291E-031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), ACI 440) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $a = 45^\circ$ and $a = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $a_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $tf_1 = NL * t / NoDir = 1.00$
 $df_v = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), ACI 440) = 328.00$
 $E_f = 82000.00$
 $f_{e_f} = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $bw * d = s * d * d / 4 = 125663.706$

 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
 #####
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.51481
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou, min} = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -7.8886091E-031$

EDGE -B-

Shear Force, $V_b = 7.8886091E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1168.672$

-Compression: $A_{sl,com} = 1168.672$

-Middle: $A_{sl,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.7881E+008$

$\mu_{u1+} = 2.7881E+008$, 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

$\mu_{u1-} = 2.7881E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.7881E+008$

$\mu_{u2+} = 2.7881E+008$, 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

$\mu_{u2-} = 2.7881E+008$, 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

$\mu_u = 2.7881E+008$

$\phi = 0.83775804$

$\phi' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$$N = 7425.858$$

$$Ac = 196349.541$$

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$

$$\text{conf. factor } c = 1.51481$$

$$f_c = 33.00$$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101313$$

$$N = 7425.858$$

$$A_c = 196349.541$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$

$$V_{Col0} = 705818.864$$

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

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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$Mu = 1.9925299E-011$$

$$Vu = 7.8886091E-031$$

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

$$Nu = 7425.858$$

$$Ag = 196349.541$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

$$A_v = \sqrt{2} \cdot A_{\text{stirup}} = 123370.055$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.25$$

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

$$A_v = \sqrt{2} \cdot A_{\text{stirup}} = 78956.835$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.04167$$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$

$$f = 0.95, \text{ for fully-wrapped sections}$$

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{A_s \cdot d}{4} = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{Col0}$
 $V_{Col0} = 705818.864$
 $k_n l = 1$ (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).

$\lambda = 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c \cdot \text{jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M / Vd = 2.00$
 $\mu_u = 1.9925299E-011$
 $\nu_u = 7.8886091E-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7425.858$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \frac{A_s}{2} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{A_s}{2} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f / s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{A_s \cdot d}{4} = 125663.706$

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: 2

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $ε_{fu} = 0.009$

Number of directions, $N_{dir} = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = -9.6280367E-011$

Shear Force, $V_2 = 4527.977$

Shear Force, $V_3 = 1.9958314E-013$

Axial Force, $F = -7424.046$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1168.672$

-Compression: $As_{c,com} = 1168.672$

-Middle: $As_{mid} = 1168.672$

Mean Diameter of Tension Reinforcement, $Db_L = 16.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03516586$

$$u = y + p = 0.03516586$$

- Calculation of y -

$$y = (My * L_s / 3) / E_{eff} = 0.00516586 \text{ ((4.29), Biskinis Phd)}$$

$$My = 2.5674E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1500.00$$

$$\text{From table 10.5, ASCE 41-17: } E_{eff} = \text{factor} * E_c * I_g = 2.4850E+013$$

$$\text{factor} = 0.30$$

$$A_g = 196349.541$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$$

$$N = 7424.046$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 8.2833E+013$$

Calculation of Yielding Moment M_y

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

$$M_y = \text{Min}(M_{y_{\text{ten}}}, M_{y_{\text{com}}}) = 2.5674E+008$$

$$y = 6.5559635E-006$$

$$M_{y_{\text{ten}}} (8c) = 2.5674E+008$$

$$y_{\text{ten}} (7c) = 63.43074$$

$$\text{error of function (7c)} = 0.00011855$$

$$M_{y_{\text{com}}} (8d) = 8.5656E+008$$

$$y_{\text{com}} (7d) = 64.71643$$

$$\text{error of function (7d)} = -0.00696577$$

$$\text{with ((10.1), ASCE 41-17) } e_y = \text{Min}(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$$

$$e_{co} = 0.002$$

$$a_{pl} = 0.45 \text{ ((9c) in Biskinis and Fardis for FRP Wrap)}$$

$$d_1 = 44.00$$

$$R = 250.00$$

$$v = 0.00101879$$

$$N = 7424.046$$

$$A_c = 196349.541$$

$$\text{((10.1), ASCE 41-17) } = \text{Min}(, 1.25 * (I_b / I_d)^{2/3}) = 0.26729306$$

$$\text{with } f_c' \text{ ((12.3), ACI 440) } = 37.11312$$

$$f_c = 33.00$$

$$f_l = 1.312$$

$$k = 1$$

$$\text{Effective FRP thickness, } t_f = N L * t * \cos(b_1) = 1.00$$

$$e_{fe} \text{ ((12.5) and (12.7)) } = 0.004$$

$$f_u = 0.009$$

$$E_f = 82000.00$$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.03$

with:

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

$$\text{shear control ratio } V_y E / V_{col} E = 0.26334747$$

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

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

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00795744$$

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

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

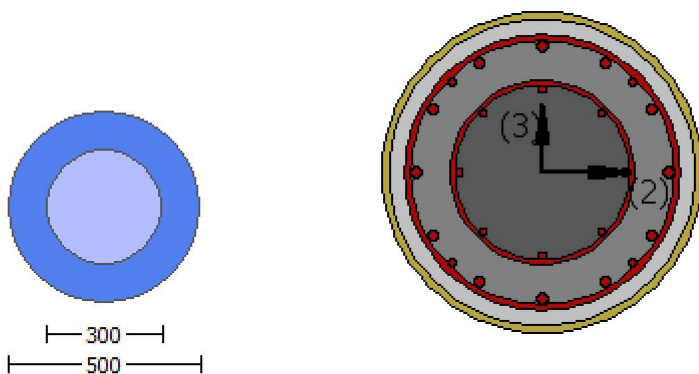
$$D_{c1} = D_{\text{ext}} - 2 * \text{cover} - \text{External Hoop Diameter} = 440.00, \text{ is the total Length of all stirrups parallel to loading (shear) direction}$$

$s1 = 100.00$
 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.
 $NUD = 7424.046$
 $Ag = 196349.541$
 $f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section_area = 33.00$
 $f_{yIE} = (f_{y,ext_Long_Reinf} * Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} * Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 2.1219958E-314$
 $f_{yTE} = (f_{y,ext_Trans_Reinf} * Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} * Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} = 555.56$
 $pI = Area_{Tot_Long_Rein} / (Ag) = 0.017856$
 $f_{cE} = 33.00$

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: Life Safety (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, $\gamma = 1.00$

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

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

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $NoDir = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 6.9521932E-010$

Shear Force, $V_a = -1.9958314E-013$

EDGE -B-

Bending Moment, $M_b = -9.6280367E-011$

Shear Force, $V_b = 1.9958314E-013$

BOTH EDGES

Axial Force, $F = -7424.046$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1168.672$

-Compression: $A_{sl,com} = 1168.672$

-Middle: $A_{sl,mid} = 1168.672$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 614527.251$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 614527.251$

$V_{CoI} = 614527.251$

$k_n = 1.00$

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: $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f'_c^{0.5} \leq 8.3$ MPa ((22.5.3.1, ACI 318-14)

$M/V_d = 2.00$

$M_u = 9.6280367E-011$

$V_u = 1.9958314E-013$

$d = 0.8 \cdot D = 400.00$

$N_u = 7424.046$

$A_g = 196349.541$

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) = 308320.00

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In ((11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

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

orientation 1: $a_1 = b_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

f_{fe} ((11-5), ACI 440) = 328.00

$E_f = 82000.00$

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

with $f_u = 0.009$

From ((11-11), ACI 440: $V_s + V_f \leq 417394.406$

$b_w \cdot d = \sqrt{4} \cdot d^2 / 4 = 125663.706$

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 $\theta = 4.9530240E-021$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00516586$ ((4.29), Biskinis Phd))

$M_y = 2.5674E+008$

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

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7424.046$
 $E_c * I_g = E_{c_jacket} * I_{g_jacket} + E_{c_core} * I_{g_core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.5674E+008$
 $\phi_y = 6.5559635E-006$
 $M_{y_ten} (8c) = 2.5674E+008$
 $\phi_{y_ten} (7c) = 63.43074$
error of function (7c) = 0.00011855
 $M_{y_com} (8d) = 8.5656E+008$
 $\phi_{y_com} (7d) = 64.71643$
error of function (7d) = -0.00696577
with ((10.1), ASCE 41-17) $\phi_y = \min(\phi_y, 1.25 * \phi_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $\phi_{co} = 0.002$
 $\phi_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101879$
 $N = 7424.046$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $\phi_y = \min(\phi_y, 1.25 * \phi_y * (I_b / I_d)^{2/3}) = 0.26729306$
with $f_c' ((12.3), ACI 440) = 37.11312$
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.00$
 $\phi_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

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

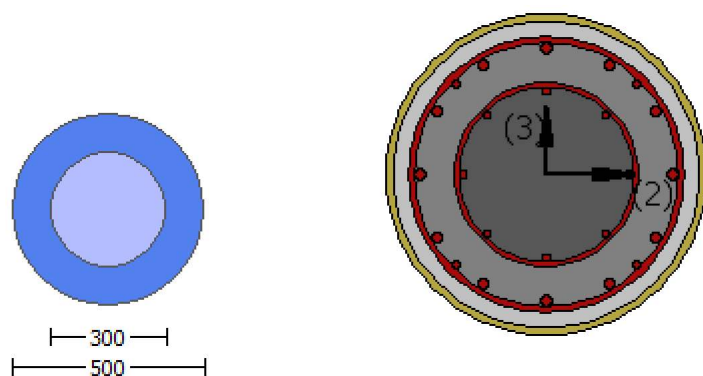
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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: rcjcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.8218291E-031$

EDGE -B-

Shear Force, $V_b = 3.8218291E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3506.017$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1168.672$

-Compression: $A_{sl,com} = 1168.672$

-Middle: $A_{sl,mid} = 1168.672$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.26334747$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$ with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.7881E+008$

$\mu_{u1+} = 2.7881E+008$, 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

$\mu_{u1-} = 2.7881E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.7881E+008$

$\mu_{u2+} = 2.7881E+008$, 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

$\mu_{u2-} = 2.7881E+008$, 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

$\mu_u = 2.7881E+008$

$\phi = 0.83775804$

$\phi' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$$N = 7425.858$$

$$Ac = 196349.541$$

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

$$= 0.83775804$$

$$' = 0.74468049$$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TDY: fcc = fc* c = 49.98874

conf. factor c = 1.51481

fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1, 1.25*(lb/d)^{2/3}) = 389.0139

lb/d = 0.30

d1 = 44.00

R = 250.00

v = 0.00101313

N = 7425.858

Ac = 196349.541

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.18607842$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.7881E+008

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 49.98874$
conf. factor $c = 1.51481$
 $f_c = 33.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
= $\cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.18607842$

Calculation of ratio lb/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$
 $V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$
 $V_{Col0} = 705818.864$
 $k_{nl} = 1$ (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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 2.00$
 $\mu_u = 1.4329951E-011$
 $\nu_u = 3.8218291E-031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7425.858$
 $A_g = 196349.541$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{A_s \cdot d}{4} = 125663.706$

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = k_n l \cdot V_{Col0}$
 $V_{Col0} = 705818.864$
 $k_n l = 1$ (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).

$\lambda = 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_c \cdot \text{jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M / Vd = 2.00$
 $\mu_u = 1.4329951 \text{E-}011$
 $\nu_u = 3.8218291 \text{E-}031$
 $d = 0.8 \cdot D = 400.00$
 $N_u = 7425.858$
 $A_g = 196349.541$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$
 $V_{s1} = 274157.871$ is calculated for jacket, with:
 $A_v = \frac{A_s}{2} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.25$
 $V_{s2} = 0.00$ is calculated for core, with:
 $A_v = \frac{A_s}{2} = 78956.835$
 $f_y = 555.56$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.04167$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 308320.00$
 $f = 0.95$, for fully-wrapped sections
 $w_f / s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression, where θ is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.00$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 470.00
 $f_{fe}((11-5), \text{ACI 440}) = 328.00$
 $E_f = 82000.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.009$
 From (11-11), ACI 440: $V_s + V_f \leq 479549.663$
 $b_w \cdot d = \frac{A_s \cdot d}{4} = 125663.706$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Diameter, $D = 500.00$

Internal Diameter, $D = 300.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.51481

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, $t = 1.00$

Tensile Strength, $f_{fu} = 840.00$

Tensile Modulus, $E_f = 82000.00$

Elongation, $\epsilon_{fu} = 0.009$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -7.8886091E-031$

EDGE -B-

Shear Force, $V_b = 7.8886091E-031$

BOTH EDGES

Axial Force, $F = -7425.858$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3506.017$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 1168.672$
-Compression: $A_{s,com} = 1168.672$
-Middle: $A_{s,mid} = 1168.672$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.26334747$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 185875.614$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 2.7881\text{E}+008$
 $\mu_{u1+} = 2.7881\text{E}+008$, 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
 $\mu_{u1-} = 2.7881\text{E}+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 2.7881\text{E}+008$
 $\mu_{u2+} = 2.7881\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 2.7881\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.7881\text{E}+008$

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 49.98874$
conf. factor $c = 1.51481$
 $f_c = 33.00$
From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101313$
 $N = 7425.858$
 $A_c = 196349.541$
= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.7881\text{E}+008$

= 0.83775804
' = 0.74468049
error of function (3.68), Biskinis Phd = 48760.493
From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 49.98874$
conf. factor $c = 1.51481$
 $f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$Ac = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

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

$\mu = 2.7881\text{E}+008$

$= 0.83775804$

$' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$Ac = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2-}

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

$\mu = 2.7881\text{E}+008$

$= 0.83775804$

$' = 0.74468049$

error of function (3.68), Biskinis Phd = 48760.493

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 49.98874$

conf. factor $c = 1.51481$

$f_c = 33.00$

From 10.3.5, ASCE 41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 250.00$

$v = 0.00101313$

$N = 7425.858$

$Ac = 196349.541$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.18607842$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 705818.864$

Calculation of Shear Strength at edge 1, $V_{r1} = 705818.864$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{ColO}$

$V_{ColO} = 705818.864$

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

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

$= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/V_d = 2.00$

$\mu_u = 1.9925299E-011$

$\nu_u = 7.8886091E-031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin \alpha + \cos \alpha$ is replaced with $(\cot \alpha + \cot \alpha) \sin \alpha$ which is more a generalised expression,

where α is the angle of the crack direction (see KANEPE).

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

orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe} \text{ ((11-5), ACI 440)} = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 705818.864$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{ColO}$

$V_{ColO} = 705818.864$

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

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

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.9925299\text{E-}011$

$\nu_u = 7.8886091\text{E-}031$

$d = 0.8 \cdot D = 400.00$

$N_u = 7425.858$

$A_g = 196349.541$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 274157.871$

$V_{s1} = 274157.871$ is calculated for jacket, with:

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.25$

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

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

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.04167$

$V_f((11-3)-(11.4), \text{ACI } 440) = 308320.00$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

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

orientation 1: $a_1 = b_1 + 90^\circ = 90.00$

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

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.00$

$d_{fv} = d$ (figure 11.2, ACI 440) = 470.00

$f_{fe}((11-5), \text{ACI } 440) = 328.00$

$E_f = 82000.00$

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

with $f_u = 0.009$

From (11-11), ACI 440: $V_s + V_f \leq 479549.663$

$b_w \cdot d = \sqrt{2} \cdot d^2 / 4 = 125663.706$

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: 3

Integration Section: (b)

Section Type: rcjcs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$
 External Diameter, $D = 500.00$
 Internal Diameter, $D = 300.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Dry properties (design values)
 Thickness, $t = 1.00$
 Tensile Strength, $f_{fu} = 840.00$
 Tensile Modulus, $E_f = 82000.00$
 Elongation, $ε_{fu} = 0.009$
 Number of directions, $N_{Dir} = 1$
 Fiber orientations, $β_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 0.08021491$
 Shear Force, $V_2 = 4527.977$
 Shear Force, $V_3 = 1.9958314E-013$
 Axial Force, $F = -7424.046$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3506.017$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1168.672$
 -Compression: $A_{sc,com} = 1168.672$
 -Middle: $A_{st,mid} = 1168.672$
 Mean Diameter of Tension Reinforcement, $D_{bL} = 16.28571$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03103317$
 $u = y + p = 0.03103317$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00103317$ ((4.29), Biskinis Phd))
 $M_y = 2.5674E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.4850E+013$
 $factor = 0.30$
 $A_g = 196349.541$
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$
 $N = 7424.046$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.2833E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y,ten}, M_{y,com}) = 2.5674E+008$
 $y = 6.5559635E-006$
 $M_{y,ten} (8c) = 2.5674E+008$

$\gamma_{ten}(7c) = 63.43074$
error of function (7c) = 0.00011855
My_com (8d) = 8.5656E+008
 $\gamma_{com}(7d) = 64.71643$
error of function (7d) = -0.00696577
with ((10.1), ASCE 41-17) $\gamma_y = \text{Min}(\gamma_y, 1.25 \cdot \gamma_y \cdot (l_b/l_d)^{2/3}) = 0.0027778$
 $\epsilon_{co} = 0.002$
 $\alpha_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 250.00$
 $v = 0.00101879$
 $N = 7424.046$
 $A_c = 196349.541$
((10.1), ASCE 41-17) $\gamma = \text{Min}(\gamma, 1.25 \cdot \gamma \cdot (l_b/l_d)^{2/3}) = 0.26729306$
with f_c^* ((12.3), ACI 440) = 37.11312
 $f_c = 33.00$
 $f_l = 1.312$
 $k = 1$
Effective FRP thickness, $t_f = N \cdot t \cdot \cos(b_1) = 1.00$
 ϵ_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.009$
 $E_f = 82000.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of ρ_p -

From table 10-9: $\rho_p = 0.03$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$
shear control ratio $V_y E / V_{colOE} = 0.26334747$
 $d = d_{external} = 0.00$
 $s = s_{external} = 0.00$
 $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00795744$
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.

$N_{UD} = 7424.046$
 $A_g = 196349.541$
 $f_{cE} = (f_{c_jacket} \cdot \text{Area_jacket} + f_{c_core} \cdot \text{Area_core}) / \text{section_area} = 33.00$
 $f_{yE} = (f_{y_ext_Long_Reinf} \cdot \text{Area_ext_Long_Reinf} + f_{y_int_Long_Reinf} \cdot \text{Area_int_Long_Reinf}) / \text{Area_Tot_Long_Rein} = 21219958E-314$
 $f_{yE} = (f_{y_ext_Trans_Reinf} \cdot \text{Area_ext_Trans_Reinf} + f_{y_int_Trans_Reinf} \cdot \text{Area_int_Trans_Reinf}) / \text{Area_Tot_Trans_Rein} = 555.56$
 $\rho_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.017856$
 $f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (b)

