Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

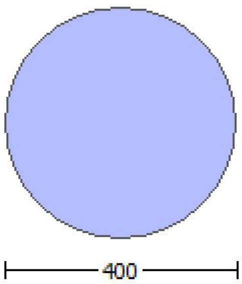
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

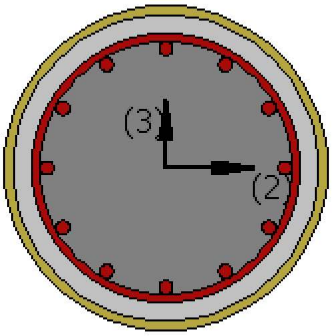
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = -1.0423E+007
Shear Force, Va = -3472.528
EDGE -B-
Bending Moment, Mb = 0.09265189
Shear Force, Vb = 3472.528
BOTH EDGES
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 235775.141
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 235775.141
VCol = 235775.141
knl = 1.00
displacement_ductility_demand = 0.01890466

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.0423E+007
Vu = 3472.528
d = 0.8*D = 320.00

Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00035245
θy = (My*Ls/3)/Eleff = 0.01864342 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.447
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4769.844
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.40642
error of function (7c) = 0.00117228
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301342
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157305
N = 4769.844
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577

with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

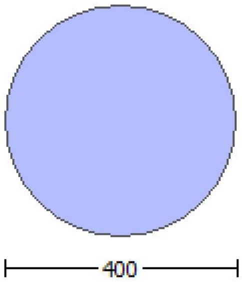
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

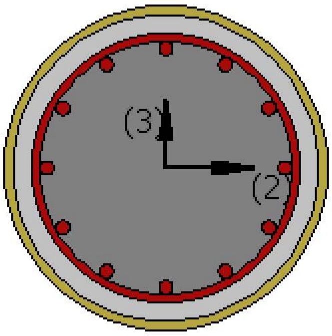
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706

ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125

Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012

Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 4.7721810E-010
Shear Force, V2 = -3472.528
Shear Force, V3 = -1.2919419E-013
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00931721
θu = θy + θp = 0.00931721

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00931721 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4769.844
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.40642
error of function (7c) = 0.00117228
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301342
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157305
N = 4769.844
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4769.844
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

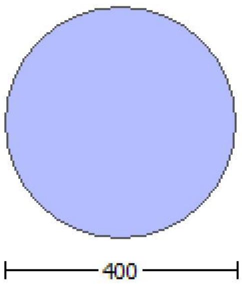
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

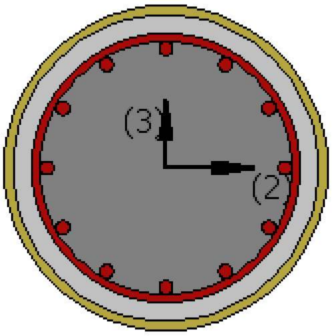
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = 4.7721810E-010
Shear Force, Va = -1.2919419E-013
EDGE -B-
Bending Moment, Mb = -8.9325839E-011
Shear Force, Vb = 1.2919419E-013
BOTH EDGES
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 286337.204
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 286337.204
VCol = 286337.204
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7721810E-010
Vu = 1.2919419E-013
d = 0.8*D = 320.00
Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.1684378E-020
θy = (My*Ls/3)/Eleff = 0.00931721 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4769.844
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.40642
error of function (7c) = 0.00117228
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301342
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157305
N = 4769.844
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

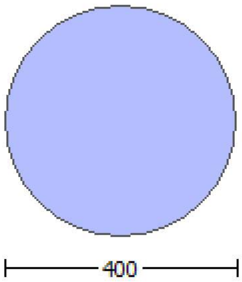
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

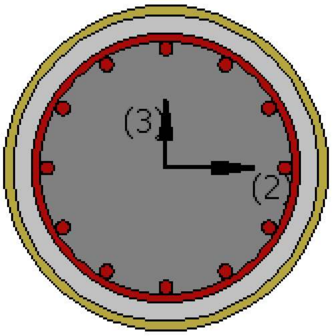
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121

φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00

Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00

Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.0423E+007
Shear Force, V2 = -3472.528
Shear Force, V3 = -1.2919419E-013
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01864342
θu = θy + θp = 0.01864342

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01864342 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.447
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30

Ag = 125663.706
fc' = 20.00
N = 4769.844
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.40642
error of function (7c) = 0.00117228
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301342
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157305
N = 4769.844
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00

ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4769.844
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

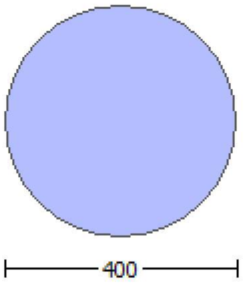
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

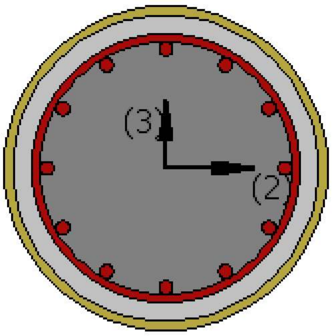
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = -1.0423E+007
Shear Force, Va = -3472.528
EDGE -B-
Bending Moment, Mb = 0.09265189
Shear Force, Vb = 3472.528
BOTH EDGES
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 286337.204
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 286337.204
VCol = 286337.204
knl = 1.00
displacement_ductility_demand = 0.10586773

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 0.09265189
Vu = 3472.528
d = 0.8*D = 320.00
Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00019728
θy = (My*Ls/3)/EIeff = 0.00186344 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4769.844
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.40642
error of function (7c) = 0.00117228
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301342
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00

v = 0.00157305
N = 4769.844
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

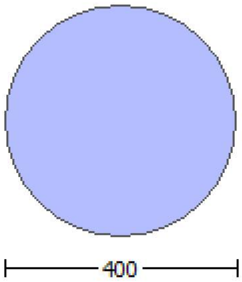
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

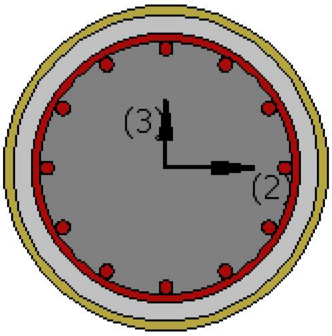
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706

ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125

Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012

Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -8.9325839E-011
Shear Force, V2 = 3472.528
Shear Force, V3 = 1.2919419E-013
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00931721
θu = θy + θp = 0.00931721

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00931721 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4769.844
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.40642
error of function (7c) = 0.00117228
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301342
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157305
N = 4769.844
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4769.844
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

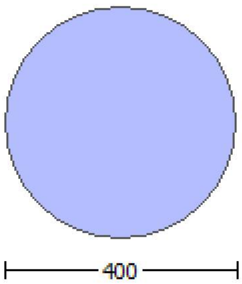
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

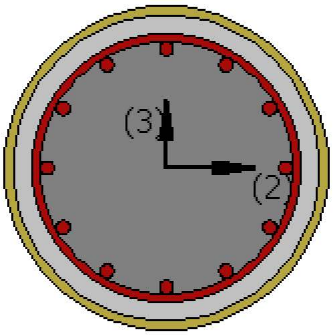
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = 4.7721810E-010
Shear Force, Va = -1.2919419E-013
EDGE -B-
Bending Moment, Mb = -8.9325839E-011
Shear Force, Vb = 1.2919419E-013
BOTH EDGES
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 286337.204
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 286337.204
VCol = 286337.204
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.9325839E-011
Vu = 1.2919419E-013
d = 0.8*D = 320.00
Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.1597918E-020
θy = (My*Ls/3)/Eleff = 0.00931721 ((4.29),Biskinis Phd))
   My = 1.4766E+008
   Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
   From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
      factor = 0.30
         Ag = 125663.706
         fc' = 20.00
         N = 4769.844
      Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
  My_ten (8c) = 1.4766E+008
  Φ_ten (7c) = 72.40642
  error of function (7c) = 0.00117228
  My_com (8d) = 3.7493E+008
  Φ_com (7d) = 69.91126
  error of function (7d) = 0.00301342
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
        eco = 0.002
        apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
        d1 = 44.00
        R = 200.00
        v = 0.00157305
        N = 4769.844
        Ac = 125663.706
       ((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
 with fc* ((12.3), ACI 440) = 24.12975
      fc = 20.00
      fl = 1.3173
      kα = 1
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
      efe ((12.5) and (12.7)) = 0.004
      εfu = 0.01
      Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   λ = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 444.44
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   ψt = 1.00
   ψs = 0.80
   ψe = 1.00
   cb = 25.00

Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

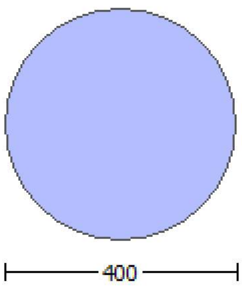
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

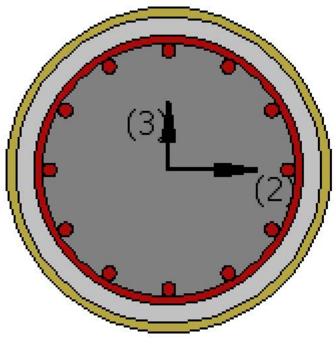
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121

φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00

Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00

Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 0.09265189
Shear Force, V2 = 3472.528
Shear Force, V3 = 1.2919419E-013
Axial Force, F = -4769.844
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00186344
θu = θy + θp = 0.00186344

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00186344 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
factor = 0.30

Ag = 125663.706
fc' = 20.00
N = 4769.844
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688007E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.40642
error of function (7c) = 0.00117228
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301342
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157305
N = 4769.844
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00

ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4769.844
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

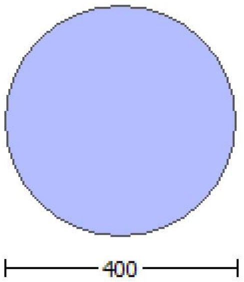
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

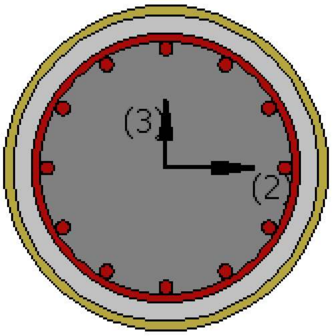
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = -1.3471E+007
Shear Force, Va = -4486.792
EDGE -B-
Bending Moment, Mb = 2684.487
Shear Force, Vb = 4486.792
BOTH EDGES
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 235776.467
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 235776.467
VCol = 235776.467
knl = 1.00
displacement_ductility_demand = 0.02901189

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 1.3471E+007
Vu = 4486.792
d = 0.8*D = 320.00
Nu = 4783.229
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00054105
θy = (My*Ls/3)/Eleff = 0.01864917 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3002.334
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00

v = 0.00157746
N = 4783.229
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

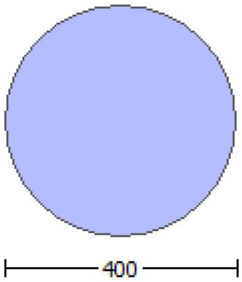
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

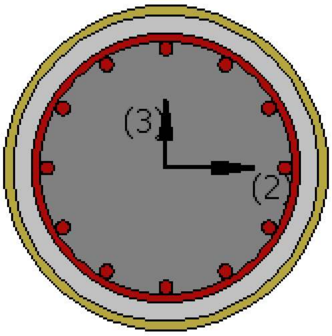
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706

ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125

Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012

Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 6.2300792E-010
Shear Force, V2 = -4486.792
Shear Force, V3 = -1.7064698E-013
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.05131733
θu = θy + θp = 0.05131733

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00931733 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157746
N = 4783.229
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4783.229
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

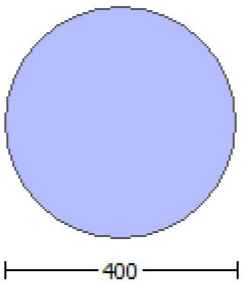
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

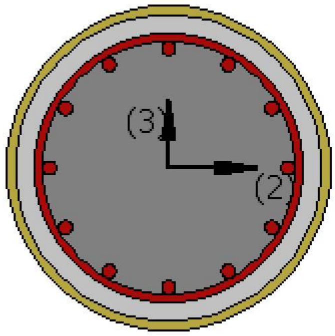
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = 6.2300792E-010
Shear Force, Va = -1.7064698E-013
EDGE -B-
Bending Moment, Mb = -1.1086227E-010
Shear Force, Vb = 1.7064698E-013
BOTH EDGES
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 286339.856
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 286339.856
VCol = 286339.856
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.2300792E-010
Vu = 1.7064698E-013
d = 0.8*D = 320.00
Nu = 4783.229
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.4283643E-020
θy = (My*Ls/3)/Eleff = 0.00931733 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157746
N = 4783.229
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

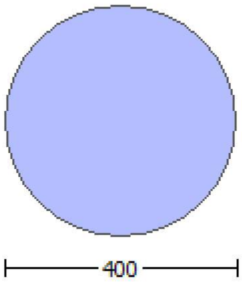
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

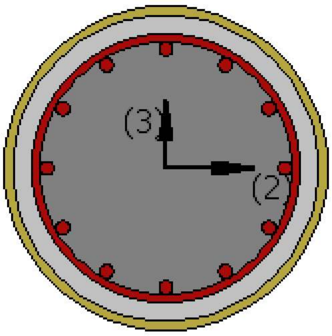
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121

φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00

Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00

Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.3471E+007
Shear Force, V2 = -4486.792
Shear Force, V3 = -1.7064698E-013
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
    -Tension: Aslt = 1272.345
    -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
    -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
    -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.06064917
θu = θy + θp = 0.06064917

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01864917 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3002.334
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30

Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

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

---

My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157746
N = 4783.229
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00

ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4783.229
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

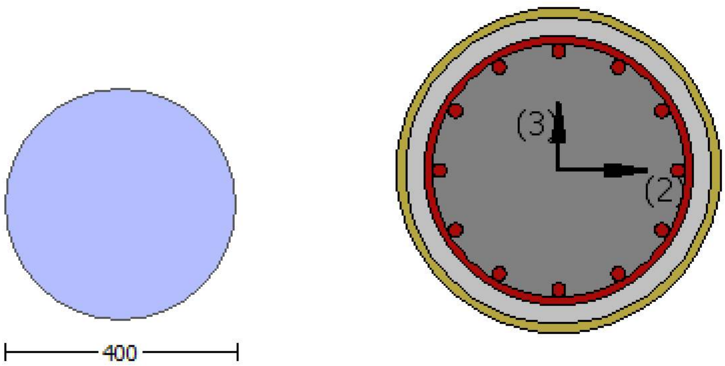
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = -1.3471E+007
Shear Force, Va = -4486.792
EDGE -B-
Bending Moment, Mb = 2684.487
Shear Force, Vb = 4486.792
BOTH EDGES
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 286339.856
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 286339.856
VCol = 286339.856
knl = 1.00
displacement_ductility_demand = 0.13687722

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 2684.487
Vu = 4486.792
d = 0.8*D = 320.00
Nu = 4783.229
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00025507
θy = (My*Ls/3)/EIeff = 0.00186347 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00

$v = 0.00157746$
$N = 4783.229$
$Ac = 125663.706$
((10.1), ASCE 41-17) $\omega = Min(\omega, 1.25*\omega*(lb/ld)^{2/3}) = 0.44757577$
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

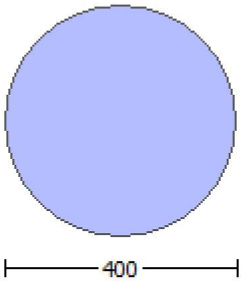
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

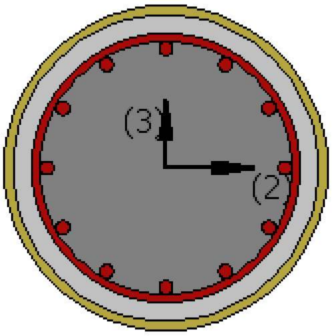
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706

ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125

Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012

Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.1086227E-010
Shear Force, V2 = 4486.792
Shear Force, V3 = 1.7064698E-013
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.05131733
θu = θy + θp = 0.05131733

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00931733 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157746
N = 4783.229
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4783.229
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

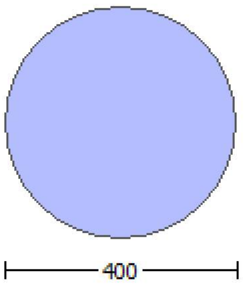
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

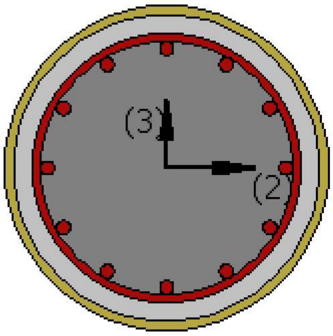
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy 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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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 = 6.2300792E-010
Shear Force, Va = -1.7064698E-013
EDGE -B-
Bending Moment, Mb = -1.1086227E-010
Shear Force, Vb = 1.7064698E-013
BOTH EDGES
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 286339.856
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 286339.856
VCol = 286339.856
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1086227E-010
Vu = 1.7064698E-013
d = 0.8*D = 320.00
Nu = 4783.229
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 213705.936
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.5066232E-020
θy = (My*Ls/3)/Eleff = 0.00931733 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
factor = 0.30
Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157746
N = 4783.229
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

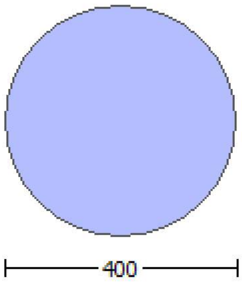
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

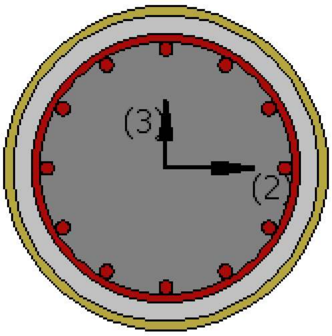
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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: 3
EDGE -A-
Shear Force, Va = 1.2107607E-031
EDGE -B-
Shear Force, Vb = -1.2107607E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121

φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286

From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00

Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2899604E-011
Vu = 1.2107607E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
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, Va = -7.4135260E-048
EDGE -B-
Shear Force, Vb = 7.4135260E-048
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.30252729
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 90202.132
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.3530E+008
Mu1+ = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.3530E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3530E+008
Mu2+ = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.3530E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.3530E+008

φ = 0.90757121
φ' = 0.80580716
error of function (3.68), Biskinis Phd = 28928.286
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 288.6089
lb/ld = 0.26792599
d1 = 44.00
R = 200.00
v = 0.00155946
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.28805051

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.26792599
lb = 300.00
ld = 1119.712
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 298161.965

Calculation of Shear Strength at edge 1, Vr1 = 298161.965
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00

Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 298161.965
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 298161.965
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.9321525E-012
Vu = 7.4135260E-048
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = π/2*A_stirrup = 123370.055
fy = 444.44
s = 360.00
Vs is multiplied by αCol = 0.00
s/d = 1.125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, κ = 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:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 2684.487
Shear Force, V2 = 4486.792
Shear Force, V3 = 1.7064698E-013
Axial Force, F = -4783.229
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.04386347
θu = θy + θp = 0.04386347

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00186347 ((4.29),Biskinis Phd))
My = 1.4766E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
factor = 0.30

Ag = 125663.706
fc' = 20.00
N = 4783.229
Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.4766E+008
Φy = 8.1688588E-006
My_ten (8c) = 1.4766E+008
Φ_ten (7c) = 72.4069
error of function (7c) = 0.00117279
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91139
error of function (7d) = 0.00300901
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157746
N = 4783.229
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44757577
with fc* ((12.3), ACI 440) = 24.12975
fc = 20.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.33490748
lb = 300.00
ld = 895.7698
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 1.14232
Atr = π/2 * Area of stirrup = 123.3701
s = 360.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.30252729
d = 0.00
s = 0.00

ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00721126
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4783.229
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
