Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

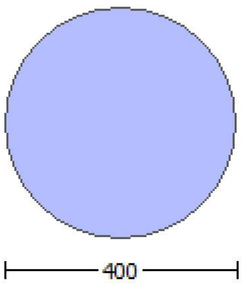
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

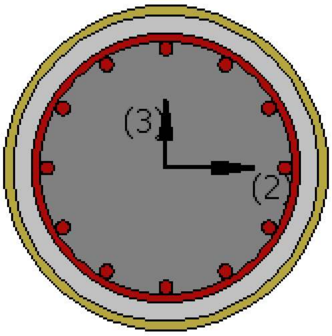
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = -8.3350E+006
Shear Force, Va = -2777.007
EDGE -B-
Bending Moment, Mb = 0.07583332
Shear Force, Vb = 2777.007
BOTH EDGES
Axial Force, F = -4770.122
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 = 224627.823
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 264268.027
VCol = 264268.027
knl = 1.00
displacement_ductility_demand = 0.01625615

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 = 8.3350E+006
Vu = 2777.007
d = 0.8*D = 320.00

Nu = 4770.122
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.00028185
θy = (My*Ls/3)/Eleff = 0.01733836 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345
error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025

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

Inadequate Lap Length with lb/ld = 0.30

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

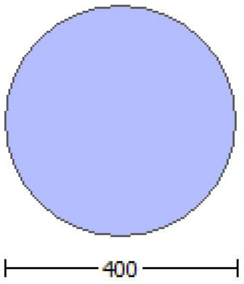
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

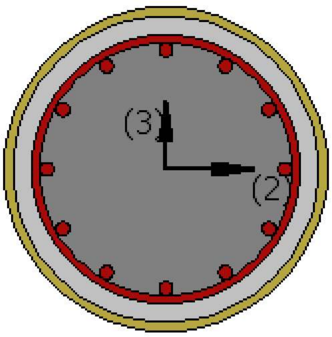
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = 2.7525396E-011
Shear Force, V2 = -2777.007
Shear Force, V3 = -1.4226804E-014

Axial Force, F = -4770.122
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 = 0.00736525
θu = θy + θp = 0.008665

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345
error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 0.27402927
  d = 0.00
  s = 0.00
  ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
  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 = 4770.122
    Ag = 125663.706
    f'cE = 20.00
    fytE = fylE = 444.4444
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

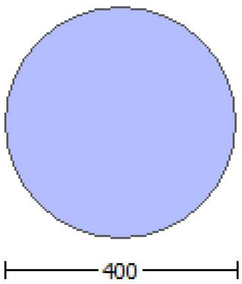
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

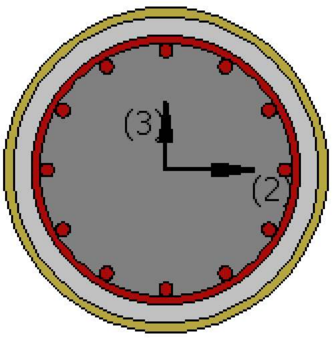
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = 2.7525396E-011
Shear Force, Va = -1.4226804E-014
EDGE -B-
Bending Moment, Mb = 1.5086324E-011
Shear Force, Vb = 1.4226804E-014
BOTH EDGES
Axial Force, F = -4770.122
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 = 267605.60
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.118

VCol = 314830.118
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 = 2.7525396E-011
Vu = 1.4226804E-014
d = 0.8*D = 320.00
Nu = 4770.122
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 4.7943297E-021
θy = (My*Ls/3)/Eleff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345

error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

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

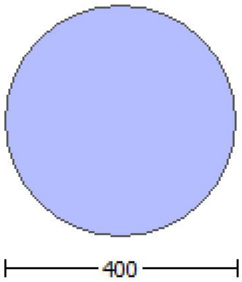
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

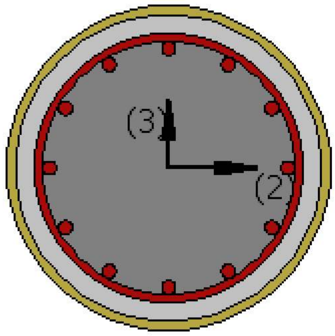
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055

fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233

Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = -8.3350E+006
Shear Force, V2 = -2777.007
Shear Force, V3 = -1.4226804E-014
Axial Force, F = -4770.122
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 = 0.01473761
θu = θy + θp = 0.01733836

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01733836 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345
error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333

with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.27402927
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
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 = 4770.122
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.4444
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

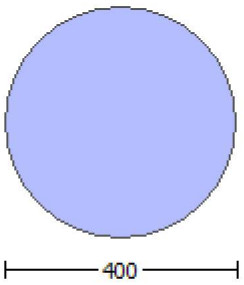
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

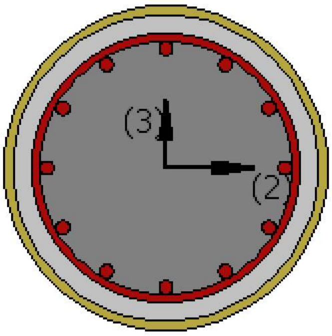
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = -8.3350E+006
Shear Force, Va = -2777.007
EDGE -B-
Bending Moment, Mb = 0.07583332
Shear Force, Vb = 2777.007
BOTH EDGES
Axial Force, F = -4770.122
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 = 267605.60
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.118
VCol = 314830.118
knl = 1.00
displacement_ductility_demand = 0.09103583

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 = 0.07583332
Vu = 2777.007
d = 0.8*D = 320.00
Nu = 4770.122
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.00015777
θy = (My*Ls/3)/EIeff = 0.001733 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345
error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

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

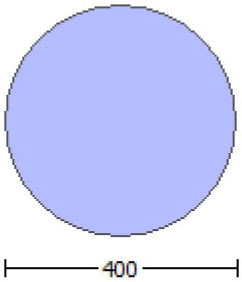
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

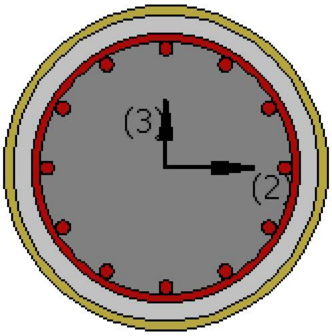
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444

s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = 1.5086324E-011
Shear Force, V2 = 2777.007
Shear Force, V3 = 1.4226804E-014
Axial Force, F = -4770.122
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 = 0.00736525
θu = θy + θp = 0.008665

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345
error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.27402927
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
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 = 4770.122
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.4444
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

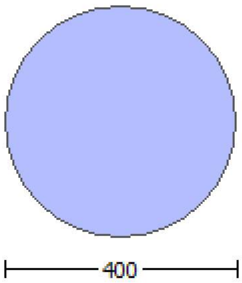
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

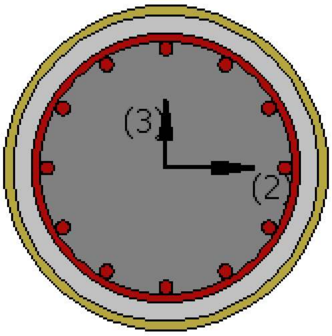
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Diameter, D = 400.00
Cover Thickness, c = 25.00

Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = 2.7525396E-011
Shear Force, Va = -1.4226804E-014
EDGE -B-
Bending Moment, Mb = 1.5086324E-011
Shear Force, Vb = 1.4226804E-014
BOTH EDGES
Axial Force, F = -4770.122
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 = 267605.60
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.118
VCol = 314830.118
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 = 1.5086324E-011
Vu = 1.4226804E-014
d = 0.8*D = 320.00
Nu = 4770.122
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 2.6179514E-022
θy = (My*Ls/3)/Eleff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345
error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

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

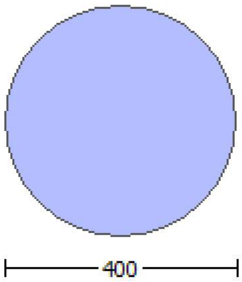
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

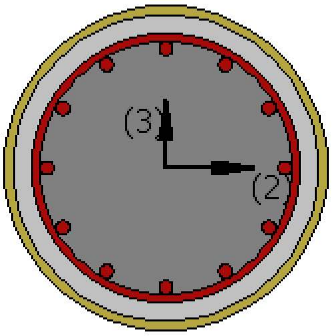
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245

φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = 0.07583332
Shear Force, V2 = 2777.007
Shear Force, V3 = 1.4226804E-014
Axial Force, F = -4770.122
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 = 0.00147305
θu = θy + θp = 0.001733

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.001733 ((4.29),Biskinis Phd))
My = 1.3732E+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 = 4770.122
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) = 1.3732E+008
Φy = 7.5716684E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23345
error of function (7c) = 0.00097594
My_com (8d) = 3.7493E+008
Φ_com (7d) = 69.91126
error of function (7d) = 0.00301333
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00222222
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00157314
N = 4770.122
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 0.27402927
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00

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 = 4770.122
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.4444
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

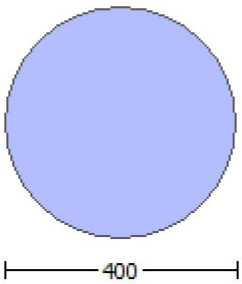
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

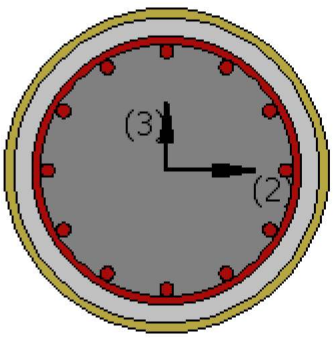
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = -3472.529
EDGE -B-
Bending Moment, Mb = 0.09482631
Shear Force, Vb = 3472.529
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 = 224627.799
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 264267.999
VCol = 264267.999
knl = 1.00
displacement_ductility_demand = 0.02032763

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 = 3472.529
d = 0.8*D = 320.00
Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.01733835 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008
Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

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

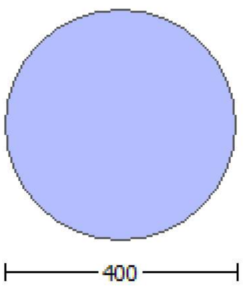
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

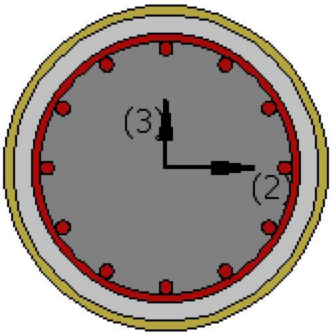
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444

s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = 3.1953177E-011
Shear Force, V2 = -3472.529
Shear Force, V3 = -1.7790009E-014
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 = 0.04306525
θu = θy + θp = 0.050665

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008
Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.27402927
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
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 = 444.4444
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

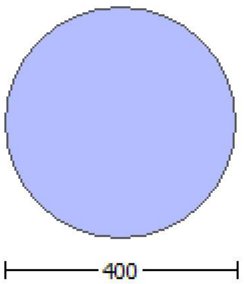
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

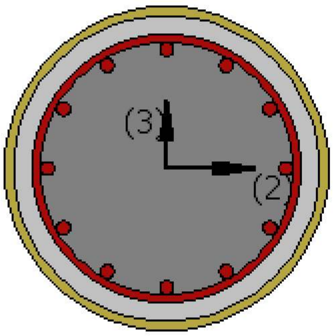
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = 3.1953177E-011
Shear Force, Va = -1.7790009E-014
EDGE -B-
Bending Moment, Mb = 2.1330954E-011
Shear Force, Vb = 1.7790009E-014
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 = 267605.553
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.062
VCol = 314830.062
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 = 3.1953177E-011
Vu = 1.7790009E-014
d = 0.8*D = 320.00
Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 5.9951039E-021
θy = (My*Ls/3)/EIeff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008

Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

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

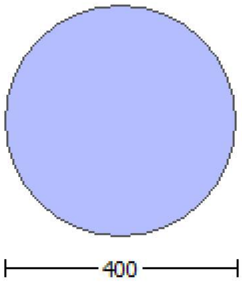
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

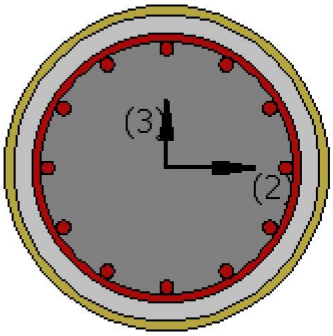
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055

fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233

Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = -3472.529
Shear Force, V3 = -1.7790009E-014
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 = 0.0504376
θu = θy + θp = 0.05933835

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01733835 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008
Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.27402927
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
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 = 444.4444
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

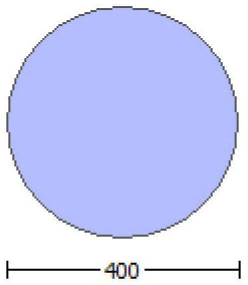
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

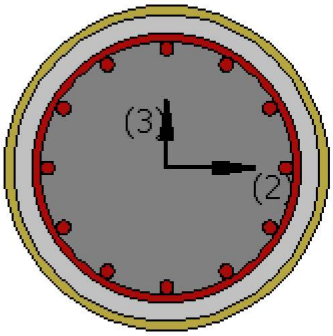
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = -3472.529
EDGE -B-
Bending Moment, Mb = 0.09482631
Shear Force, Vb = 3472.529
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 = 267605.553
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.062
VCol = 314830.062
knl = 1.00
displacement_ductility_demand = 0.11383644

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 = 0.09482631
Vu = 3472.529
d = 0.8*D = 320.00
Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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)/Eleff = 0.001733 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008
Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

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

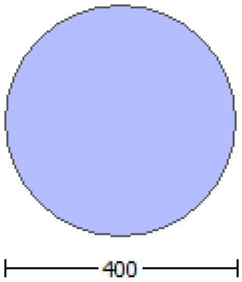
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

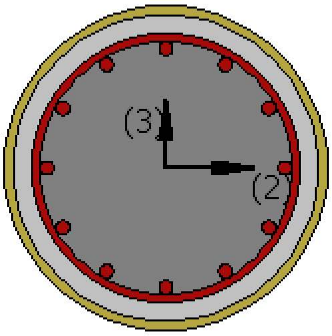
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444

s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = 2.1330954E-011
Shear Force, V2 = 3472.529
Shear Force, V3 = 1.7790009E-014
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 = 0.04306525
θu = θy + θp = 0.050665

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008
Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.27402927
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
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 = 444.4444
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

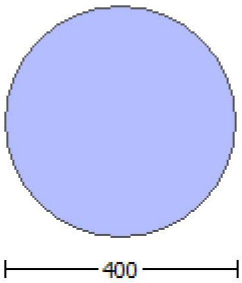
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

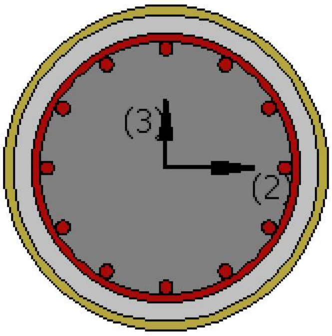
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
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, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Diameter, D = 400.00
Cover Thickness, c = 25.00

Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
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 = 3.1953177E-011
Shear Force, Va = -1.7790009E-014
EDGE -B-
Bending Moment, Mb = 2.1330954E-011
Shear Force, Vb = 1.7790009E-014
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 = 267605.553
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.062
VCol = 314830.062
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 = 2.1330954E-011
Vu = 1.7790009E-014
d = 0.8*D = 320.00
Nu = 4769.844
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 3.2736361E-022
θy = (My*Ls/3)/EIeff = 0.008665 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008
Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

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

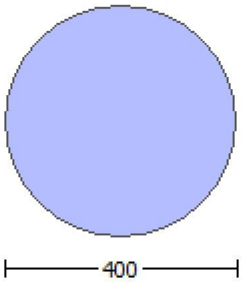
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

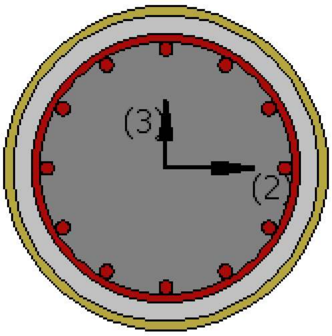
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = -3.7968243E-031
EDGE -B-
Shear Force, Vb = 3.7968243E-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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245

φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.8466009E-012
Vu = 3.7968243E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.84055
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
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 = 4.4296389E-033
EDGE -B-
Shear Force, Vb = -4.4296389E-033
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 = 0.27402927
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 96425.251
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4464E+008
Mu1+ = 1.4464E+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- = 1.4464E+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-) = 1.4464E+008
Mu2+ = 1.4464E+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- = 1.4464E+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 = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4464E+008

φ = 0.9250245
φ' = 0.82105152
error of function (3.68), Biskinis Phd = 31682.903
From 5A.2, TBDY: fcc = fc*λc = 36.81095
conf. factor λc = 1.84055
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 311.2087
lb/ld = 0.30
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) = 0.31060654

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 351879.387
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 = 9.0356326E-012
Vu = 4.4296389E-033
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175459.634
Av = π/2*A_stirrup = 123370.055
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
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 = 444.4444
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
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
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 = 0.09482631
Shear Force, V2 = 3472.529
Shear Force, V3 = 1.7790009E-014
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 = 0.03717305
θu = θy + θp = 0.043733

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.001733 ((4.29),Biskinis Phd))
My = 1.3732E+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) = 1.3732E+008
Φy = 7.5716672E-006
My_ten (8c) = 1.3732E+008
Φ_ten (7c) = 72.23344
error of function (7c) = 0.00097593
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) = 0.00222222
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) = 0.44758025
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

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.27402927
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00

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 = 444.4444
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)
