Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

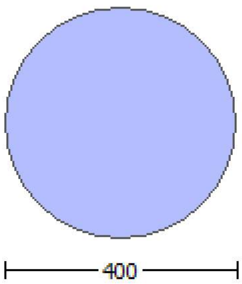
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

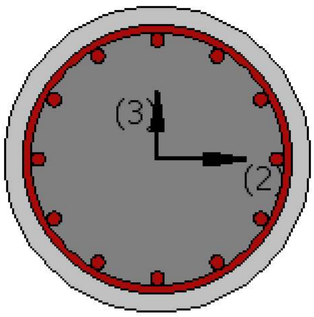
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062

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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
##
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -8.6921E+006
Shear Force, Va = -2896.171
EDGE -B-
Bending Moment, Mb = 0.01610134
Shear Force, Vb = 2896.171
BOTH EDGES
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 214387.999
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 214387.999
VCol = 214387.999
knl = 1.00
displacement_ductility_demand = 0.02304809

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 = 4.00
Mu = 8.6921E+006
Vu = 2896.171
d = 0.8*D = 320.00
Nu = 4770.074
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50

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 = 0.00025199
θy = (My*Ls/3)/EIeff = 0.01093316 ((4.29),Biskinis Phd))
My = 1.0246E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.241
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 2

column C1, Floor 1

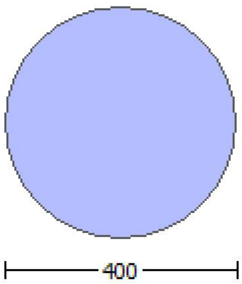
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

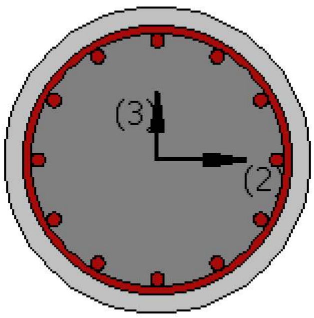
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00

Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 6.2743575E-010
Shear Force, V2 = -2896.171
Shear Force, V3 = -2.2487963E-013
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00546432
θu = θy + θp = 0.00546432

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00546432 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748

My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

- 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 = 0.23120003
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 = 4770.074
Ag = 125663.706
f'cE = 28.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 28.00

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

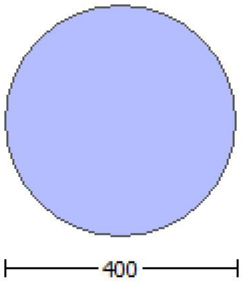
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

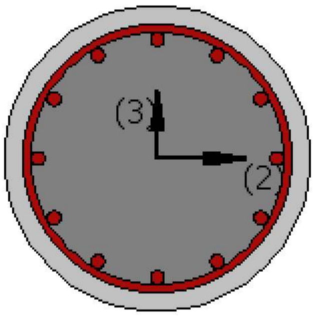
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062
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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
###
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 6.2743575E-010
Shear Force, Va = -2.2487963E-013
EDGE -B-
Bending Moment, Mb = 4.7467405E-011
Shear Force, Vb = 2.2487963E-013
BOTH EDGES
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 270862.328
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 270862.328
VCol = 270862.328
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.2743575E-010
Vu = 2.2487963E-013
d = 0.8*D = 320.00
Nu = 4770.074
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

----

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.8534978E-020
θy = (My*Ls/3)/Eleff = 0.00546432 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074

Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 4

column C1, Floor 1

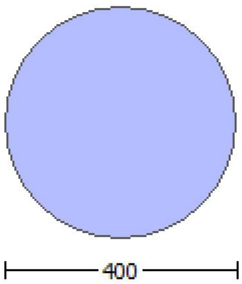
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

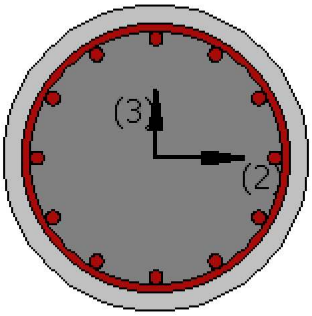
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659

d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00

v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234

Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -8.6921E+006
Shear Force, V2 = -2896.171
Shear Force, V3 = -2.2487963E-013
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.01093316
θu = θy + θp = 0.01093316

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01093316 ((4.29),Biskinis Phd))
My = 1.0246E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.241
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 λ = 1
 db = 18.00
 Mean strength value of all re-bars: fy = 420.00
 fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
 ψt = 1.00
 ψs = 0.80
 ψe = 1.00
 cb = 25.00
 Ktr = 4.11234
  Atr = π/2 * Area of stirrup = 123.3701
  s = 100.00
  n = 12.00

- 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 = 0.23120003
 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 = 4770.074
  Ag = 125663.706
  f'cE = 28.00
  fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
  f'cE = 28.00

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

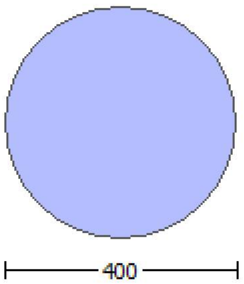
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

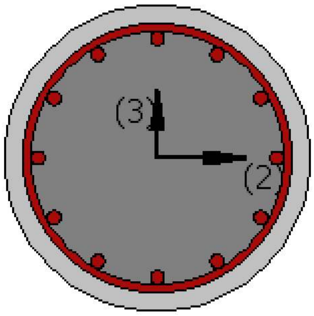
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062
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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
###
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -8.6921E+006
Shear Force, Va = -2896.171

EDGE -B-
Bending Moment, Mb = 0.01610134
Shear Force, Vb = 2896.171
BOTH EDGES
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 270862.328
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 270862.328
VCol = 270862.328
knl = 1.00
displacement_ductility_demand = 0.12723254

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 = 0.01610134
Vu = 2896.171
d = 0.8*D = 320.00
Nu = 4770.074
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
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 = 0.00013905
θy = (My*Ls/3)/EIeff = 0.00109286 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 6

column C1, Floor 1

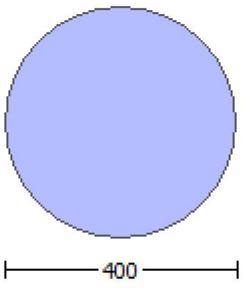
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

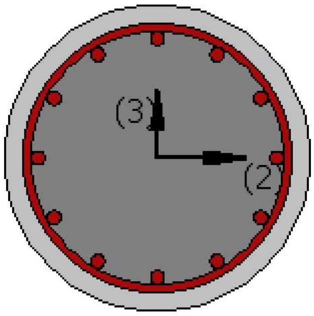
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659

d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00

v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234

Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 4.7467405E-011
Shear Force, V2 = 2896.171
Shear Force, V3 = 2.2487963E-013
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00546432
θu = θy + θp = 0.00546432

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00546432 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

- 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 = 0.23120003
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 = 4770.074
Ag = 125663.706
f'cE = 28.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 28.00

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

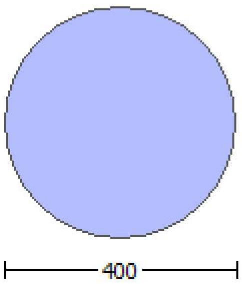
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

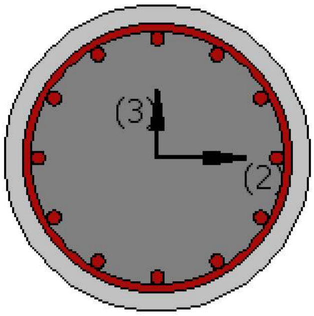
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062
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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
###
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 6.2743575E-010
Shear Force, Va = -2.2487963E-013

EDGE -B-
Bending Moment, Mb = 4.7467405E-011
Shear Force, Vb = 2.2487963E-013
BOTH EDGES
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 270862.328
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 270862.328
VCol = 270862.328
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7467405E-011
Vu = 2.2487963E-013
d = 0.8*D = 320.00
Nu = 4770.074
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
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 = 8.2463842E-021
θy = (My*Ls/3)/EIeff = 0.00546432 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 8

column C1, Floor 1

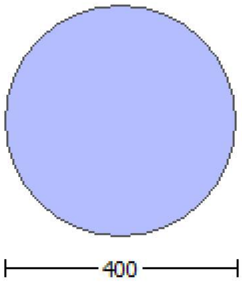
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

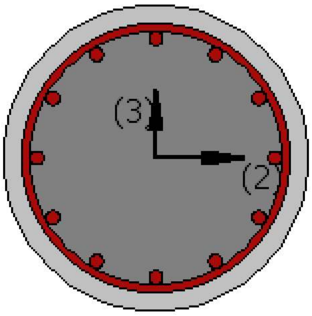
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659

d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00

v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234

Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 0.01610134
Shear Force, V2 = 2896.171
Shear Force, V3 = 2.2487963E-013
Axial Force, F = -4770.074
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00109286
θu = θy + θp = 0.00109286

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00109286 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946610E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92779
error of function (7c) = 0.00012748
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01017
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

- 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 = 0.23120003
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 = 4770.074
Ag = 125663.706
f'cE = 28.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 28.00

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

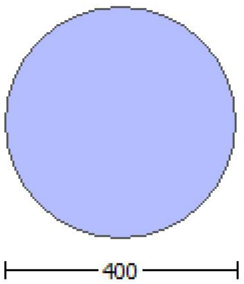
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

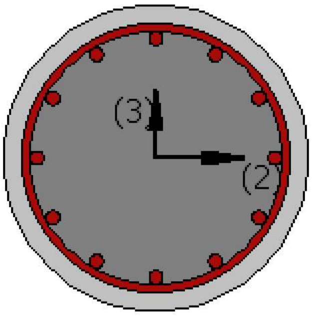
Analysis: Uniform +X

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 = 1.00
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:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062
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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
##
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.3765E+007
Shear Force, Va = -4586.336

EDGE -B-
Bending Moment, Mb = 0.02549785
Shear Force, Vb = 4586.336
BOTH EDGES
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 214387.932
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 214387.932
VCol = 214387.932
knl = 1.00
displacement_ductility_demand = 0.03649867

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 = 4.00
Mu = 1.3765E+007
Vu = 4586.336
d = 0.8*D = 320.00
Nu = 4769.398
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
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 = 0.00039905
θy = (My*Ls/3)/EIeff = 0.01093315 ((4.29),Biskinis Phd))
My = 1.0246E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.241
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 10

column C1, Floor 1

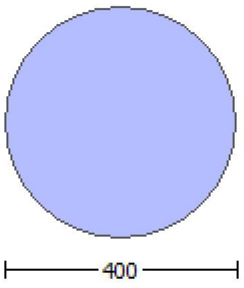
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

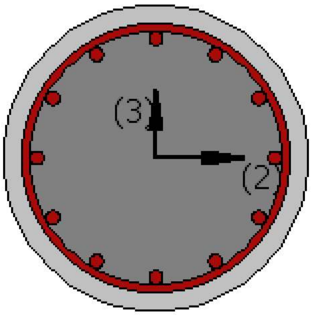
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659

d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00

v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234

Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 9.8764457E-010
Shear Force, V2 = -4586.336
Shear Force, V3 = -3.5611621E-013
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.04672222
θu = θy + θp = 0.04672222

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00546431 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.04125791
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.23120003
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 = 4769.398
Ag = 125663.706
f'cE = 28.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 28.00

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

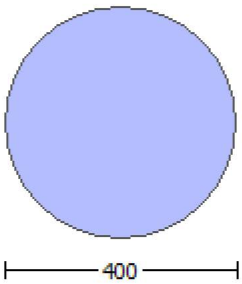
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

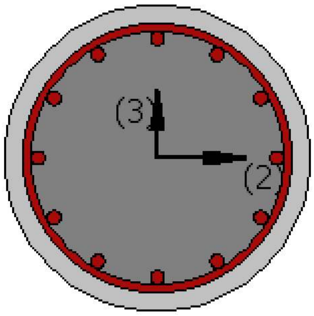
Analysis: Uniform +X

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 = 1.00
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:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062
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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
###
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 9.8764457E-010
Shear Force, Va = -3.5611621E-013

EDGE -B-
Bending Moment, Mb = 8.1122560E-011
Shear Force, Vb = 3.5611621E-013
BOTH EDGES
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 270862.194
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 270862.194
VCol = 270862.194
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.8764457E-010
Vu = 3.5611621E-013
d = 0.8*D = 320.00
Nu = 4769.398
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.9351730E-020
θy = (My*Ls/3)/Eleff = 0.00546431 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 12

column C1, Floor 1

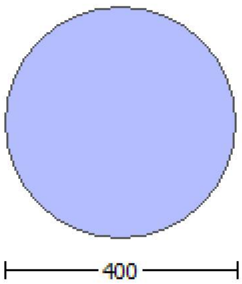
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

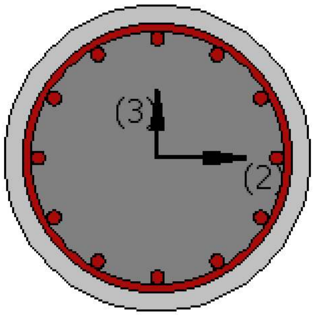
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659

d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00

v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234

Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.3765E+007
Shear Force, V2 = -4586.336
Shear Force, V3 = -3.5611621E-013
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.05219106
θu = θy + θp = 0.05219106

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01093315 ((4.29),Biskinis Phd))
My = 1.0246E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.241
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.04125791
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.23120003
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 = 4769.398
Ag = 125663.706
f'cE = 28.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 28.00

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

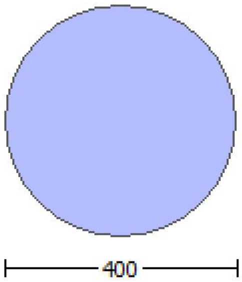
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

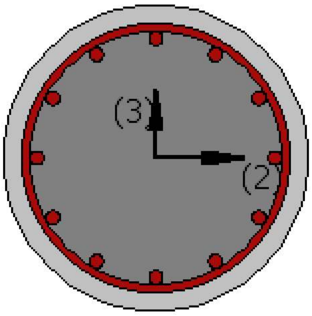
Analysis: Uniform +X

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 = 1.00
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:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062
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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
###
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.3765E+007
Shear Force, Va = -4586.336

EDGE -B-
Bending Moment, Mb = 0.02549785
Shear Force, Vb = 4586.336
BOTH EDGES
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 270862.194
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 270862.194
VCol = 270862.194
knl = 1.00
displacement_ductility_demand = 0.20148387

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 = 0.02549785
Vu = 4586.336
d = 0.8*D = 320.00
Nu = 4769.398
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
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 = 0.00022019
θy = (My*Ls/3)/EIeff = 0.00109286 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 14

column C1, Floor 1

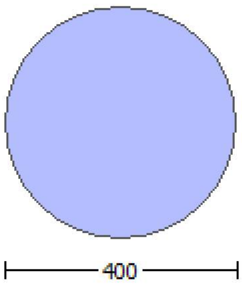
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

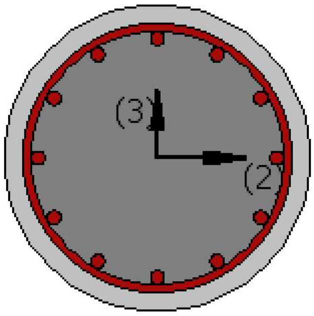
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659

d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00

v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234

Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 8.1122560E-011
Shear Force, V2 = 4586.336
Shear Force, V3 = 3.5611621E-013
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.04672222
θu = θy + θp = 0.04672222

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00546431 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.04125791
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.23120003
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 = 4769.398
Ag = 125663.706
f'cE = 28.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 28.00

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

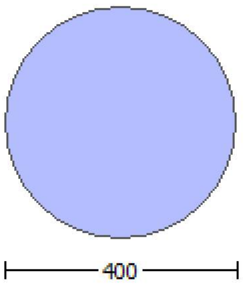
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

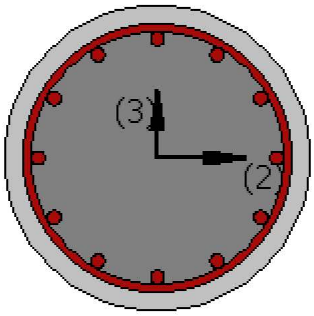
Analysis: Uniform +X

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 = 1.00
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:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 24870.062
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).
New material: Concrete Strength, fc = fcm = 28.00
New material: Steel Strength, fs = fsm = 420.00
###
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
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 9.8764457E-010
Shear Force, Va = -3.5611621E-013

EDGE -B-
Bending Moment, Mb = 8.1122560E-011
Shear Force, Vb = 3.5611621E-013
BOTH EDGES
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 270862.194
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 270862.194
VCol = 270862.194
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.1122560E-011
Vu = 3.5611621E-013
d = 0.8*D = 320.00
Nu = 4769.398
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) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = π*d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.3058858E-020
θy = (My*Ls/3)/EIeff = 0.00546431 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

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

Calculation No. 16

column C1, Floor 1

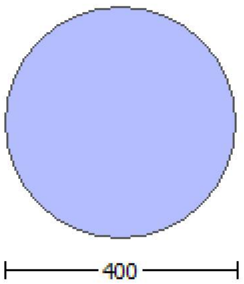
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

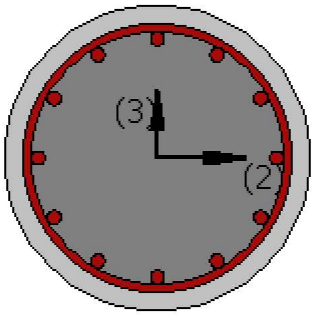
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.4905454E-031
EDGE -B-
Shear Force, Vb = -5.4905454E-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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659

d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0202174E-011
Vu = 5.4905454E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
New material: Steel Strength, fs = 1.25*fsm = 525.00
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.3618784E-047
EDGE -B-
Shear Force, Vb = 3.3618784E-047
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 = 0.23120003
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 69193.268
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0379E+008
Mu1+ = 1.0379E+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- = 1.0379E+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-) = 1.0379E+008
Mu2+ = 1.0379E+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- = 1.0379E+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 = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00

v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234

Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.0379E+008

φ = 0.83775804
φ' = 0.74468049
error of function (3.68), Biskinis Phd = 18810.485
From 5A.2, TBDY: fcc = fc*λc = 37.11712
conf. factor λc = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 214.437
lb/ld = 0.18678659
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4771.233
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.14888057

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.18678659
lb = 300.00
ld = 1606.111
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 525.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047

d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
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' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5758480E-012
Vu = 3.3618784E-047
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = π*d*d/4 = 80424.772

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 0.02549785
Shear Force, V2 = 4586.336
Shear Force, V3 = 3.5611621E-013
Axial Force, F = -4769.398
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.04235077
θu = θy + θp = 0.04235077

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00109286 ((4.29),Biskinis Phd))
My = 1.0246E+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 = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+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) = 1.0246E+008
Φy = 5.2946585E-006
My_ten (8c) = 1.0246E+008
Φ_ten (7c) = 70.92776
error of function (7c) = 0.00012747
My_com (8d) = 4.0201E+008
Φ_com (7d) = 69.01016
error of function (7d) = -0.00040881
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.3645
with fc = 28.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.23348324
lb = 300.00
ld = 1284.889
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 420.00
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.04125791
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.23120003
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 = 4769.398
Ag = 125663.706
f'cE = 28.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 28.00

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