Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

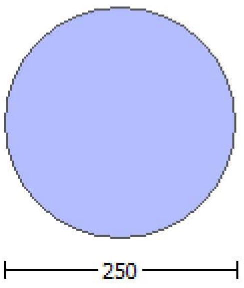
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

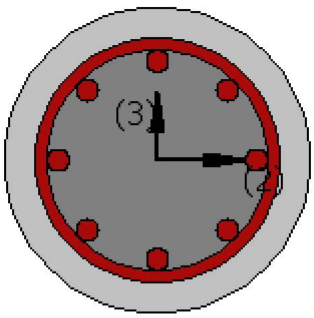
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
##
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.1383E+008
Shear Force, Va = -13811.232
EDGE -B-
Bending Moment, Mb = -2.7545E+006
Shear Force, Vb = 13811.232
BOTH EDGES
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 106229.026
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 106229.026
VCol = 106229.026
knl = 1.00
displacement_ductility_demand = 0.78158346

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.1383E+008
Vu = 13811.232
d = 0.8*D = 200.00
Nu = 445912.906
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85

bw*d = π*d*d/4 = 31415.927

----
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 = 0.05611299
θy = (My*Ls/3)/Eleff = 0.07179399 ((4.29),Biskinis Phd))
My = 8.7706E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749
error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60560421
N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 2

column C1, Floor 1

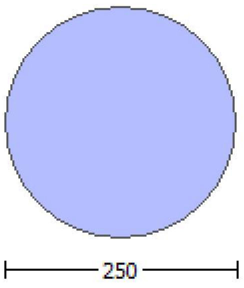
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

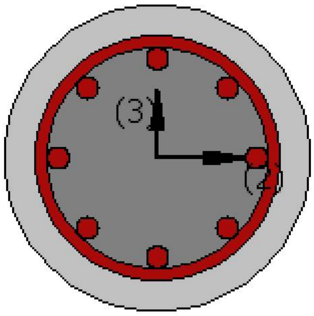
Analysis: Uniform +X

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 6.9705861E-031
EDGE -B-
Shear Force, Vb = -6.9705861E-031

BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517

error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026

N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 4.9525674E-029
EDGE -B-
Shear Force, Vb = -4.9525674E-029
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022

Steel Elasticity, Es = 200000.00
Diameter, D = 250.00
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
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.6605669E-007
Shear Force, V2 = -13811.232
Shear Force, V3 = 5.3025751E-011
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 0.02130332
θu = θy + θp = 0.02130332

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0179485 ((4.29),Biskinis Phd))
My = 8.7706E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749
error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60560421

N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.00335482
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.32556294
d = 209.00
s = 150.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00826735
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 190.00
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 = 445912.906
Ag = 49087.385
f'cE = 15.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.041472
f'cE = 15.00

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

Calculation No. 3

column C1, Floor 1

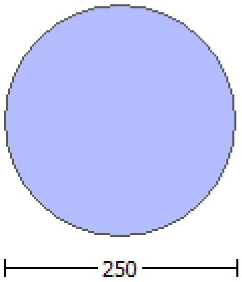
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

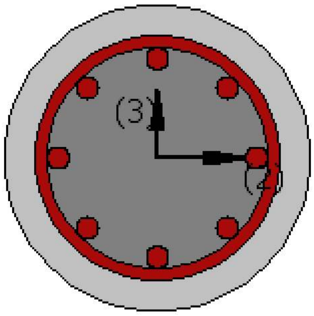
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
##
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.6605669E-007
Shear Force, Va = 5.3025751E-011
EDGE -B-
Bending Moment, Mb = -2.0276336E-008
Shear Force, Vb = -5.3025751E-011
BOTH EDGES
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 146462.202
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 146462.202
VCol = 146462.202
knl = 1.00
displacement_ductility_demand = 1.1102230E-015

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6605669E-007
Vu = 5.3025751E-011
d = 0.8*D = 200.00
Nu = 445912.906
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85
bw*d = π*d*d/4 = 31415.927

----
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 = 2.0398378E-017
θy = (My*Ls/3)/Eleff = 0.0179485 ((4.29),Biskinis Phd))
My = 8.7706E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749
error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00

R = 125.00
v = 0.60560421
N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 4

column C1, Floor 1

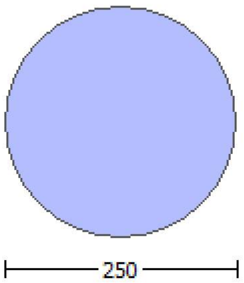
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

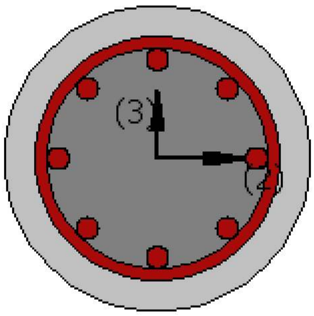
Analysis: Uniform +X

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022

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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 6.9705861E-031
EDGE -B-
Shear Force, Vb = -6.9705861E-031
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465

fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 4.9525674E-029
EDGE -B-
Shear Force, Vb = -4.9525674E-029
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00

s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Diameter, D = 250.00
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
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.1383E+008
Shear Force, V2 = -13811.232
Shear Force, V3 = 5.3025751E-011
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 0.07514881
θu = θy + θp = 0.07514881

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.07179399 ((4.29),Biskinis Phd))
My = 8.7706E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4433E+012

factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

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

---

My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749
error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60560421
N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.00335482
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.32556294
d = 209.00
s = 150.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00826735
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 190.00
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 = 445912.906
Ag = 49087.385
f'cE = 15.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.041472
f'cE = 15.00

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

Calculation No. 5

column C1, Floor 1

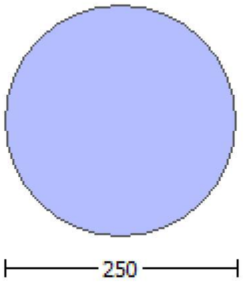
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

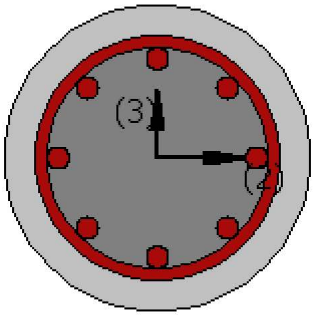
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
###
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.1383E+008
Shear Force, Va = -13811.232
EDGE -B-
Bending Moment, Mb = -2.7545E+006
Shear Force, Vb = 13811.232
BOTH EDGES
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 120597.39
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 120597.39
VCol = 146462.202
knl = 0.82340282
displacement_ductility_demand = 4.35463

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7545E+006
Vu = 13811.232
d = 0.8*D = 200.00
Nu = 445912.906
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85
bw*d = π*d*d/4 = 31415.927

----

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 = 0.01563181
θy = (My*Ls/3)/EIeff = 0.0035897 ((4.29),Biskinis Phd))
My = 8.7706E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906

Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

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

----

My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749
error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60560421
N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 6

column C1, Floor 1

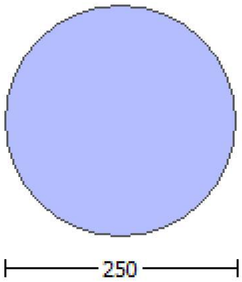
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

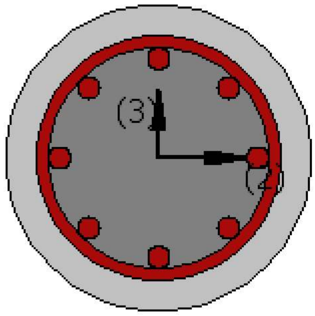
Analysis: Uniform +X

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 6.9705861E-031
EDGE -B-
Shear Force, Vb = -6.9705861E-031
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 4.9525674E-029
EDGE -B-
Shear Force, Vb = -4.9525674E-029
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00

lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00

Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Diameter, D = 250.00
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
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.0276336E-008
Shear Force, V2 = 13811.232
Shear Force, V3 = -5.3025751E-011
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 0.02130332
θu = θy + θp = 0.02130332

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0179485 ((4.29),Biskinis Phd))
My = 8.7706E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749
error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60560421
N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.00335482
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VCol0E = 0.32556294
   d = 209.00
   s = 150.00
   ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00826735
   Av = 78.53982, is the area of the circular stirrup
   dc = D - 2*cover - Hoop Diameter = 190.00
   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 = 445912.906
     Ag = 49087.385
     f'cE = 15.00
     fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.041472
     f'cE = 15.00

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

Calculation No. 7

column C1, Floor 1

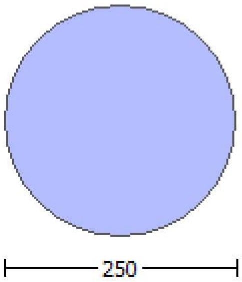
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

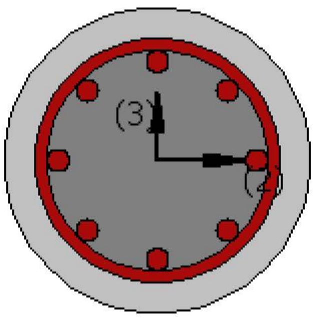
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
###
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.6605669E-007
Shear Force, Va = 5.3025751E-011
EDGE -B-
Bending Moment, Mb = -2.0276336E-008
Shear Force, Vb = -5.3025751E-011
BOTH EDGES
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 146462.202
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 146462.202
VCol = 146462.202
knl = 1.00
displacement_ductility_demand = 3.3306691E-016

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0276336E-008
Vu = 5.3025751E-011
d = 0.8*D = 200.00
Nu = 445912.906

Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85
bw*d = π*d*d/4 = 31415.927

----
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 = 8.1463217E-018
θy = (My*Ls/3)/EIeff = 0.0179485 ((4.29),Biskinis Phd))
My = 8.7706E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749
error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60560421
N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 8

column C1, Floor 1

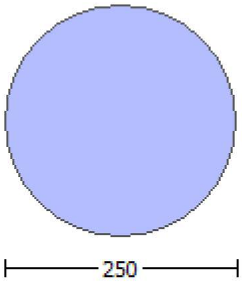
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

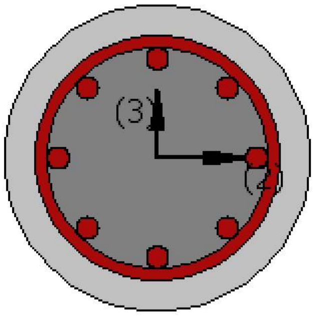
Analysis: Uniform +X

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 6.9705861E-031
EDGE -B-
Shear Force, Vb = -6.9705861E-031
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746

conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00

s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 4.9525674E-029
EDGE -B-
Shear Force, Vb = -4.9525674E-029
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294

Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Diameter, D = 250.00
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
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.7545E+006
Shear Force, V2 = 13811.232
Shear Force, V3 = -5.3025751E-011
Axial Force, F = -445912.906
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 0.00694452
θu = θy + θp = 0.00694452

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0035897 ((4.29),Biskinis Phd))
My = 8.7706E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 445912.906
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7706E+007
Φy ((10a) or (10b)) = 2.6393238E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.79972212
My_com (8b) = 8.7706E+007
Φ_com (7b) = 84.79749

error of function (7b) = -0.00558676
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60560421
N = 445912.906
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.00335482
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.32556294
d = 209.00
s = 150.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00826735
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 190.00
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 = 445912.906
Ag = 49087.385
f'cE = 15.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.041472
f'cE = 15.00

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

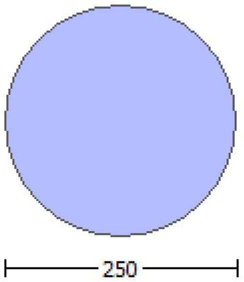
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

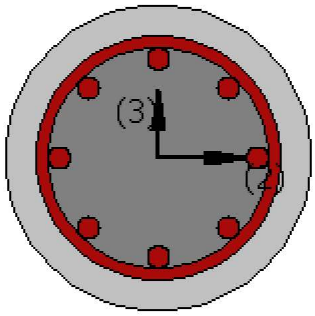
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
##
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -7.8578E+007
Shear Force, Va = -11112.547
EDGE -B-
Bending Moment, Mb = -2.2238E+006
Shear Force, Vb = 11112.547
BOTH EDGES
Axial Force, F = -446381.238
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 106247.027
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 106247.027
VCol = 106247.027
knl = 1.00
displacement_ductility_demand = 0.49362403

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 7.8578E+007
Vu = 11112.547
d = 0.8*D = 200.00
Nu = 446381.238
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85
bw*d = π*d*d/4 = 31415.927

----
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 = 0.03543875
θy = (My*Ls/3)/Eleff = 0.071793 ((4.29),Biskinis Phd))
My = 8.7705E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 446381.238
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7705E+007
Φy ((10a) or (10b)) = 2.6387582E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.80035817
My_com (8b) = 8.7705E+007
Φ_com (7b) = 84.80871
error of function (7b) = -0.00559928
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00

R = 125.00
v = 0.60624026
N = 446381.238
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

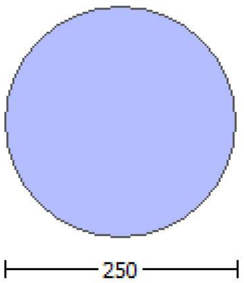
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

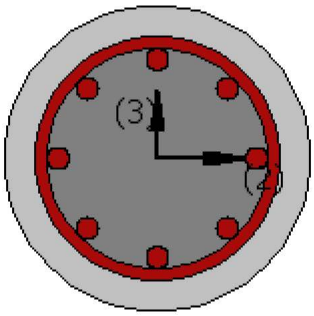
Analysis: Uniform +X

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022

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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 6.9705861E-031
EDGE -B-
Shear Force, Vb = -6.9705861E-031
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465

fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 4.9525674E-029
EDGE -B-
Shear Force, Vb = -4.9525674E-029
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00

s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Diameter, D = 250.00
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
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -7.2190302E-008
Shear Force, V2 = -11112.547
Shear Force, V3 = 2.2804883E-011
Axial Force, F = -446381.238
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 0.04236858
θu = θy + θp = 0.04236858

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.01794825 ((4.29),Biskinis Phd))
My = 8.7705E+007
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 = 2.4433E+012

factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 446381.238
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7705E+007
Φy ((10a) or (10b)) = 2.6387582E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.80035817
My_com (8b) = 8.7705E+007
Φ_com (7b) = 84.80871
error of function (7b) = -0.00559928
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60624026
N = 446381.238
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.02442033
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.32556294
d = 209.00
s = 150.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00826735
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 190.00
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 = 446381.238
Ag = 49087.385
f'cE = 15.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.041472
f'cE = 15.00

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

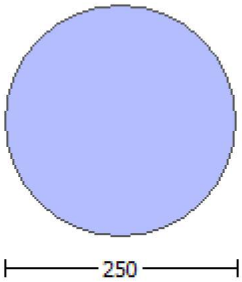
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

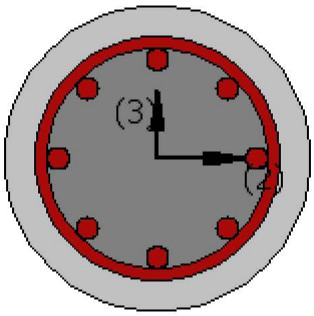
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
###
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -7.2190302E-008
Shear Force, Va = 2.2804883E-011
EDGE -B-
Bending Moment, Mb = -8.7641823E-009
Shear Force, Vb = -2.2804883E-011
BOTH EDGES
Axial Force, F = -446381.238
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 146498.205
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 146498.205
VCol = 146498.205
knl = 1.00
displacement_ductility_demand = 5.5511151E-016

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.2190302E-008
Vu = 2.2804883E-011
d = 0.8*D = 200.00
Nu = 446381.238
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85
bw*d = π*d*d/4 = 31415.927

----

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 = 9.3830441E-018
θy = (My*Ls/3)/EIeff = 0.01794825 ((4.29),Biskinis Phd))
My = 8.7705E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 446381.238

Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7705E+007
Φy ((10a) or (10b)) = 2.6387582E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.80035817
My_com (8b) = 8.7705E+007
Φ_com (7b) = 84.80871
error of function (7b) = -0.00559928
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60624026
N = 446381.238
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

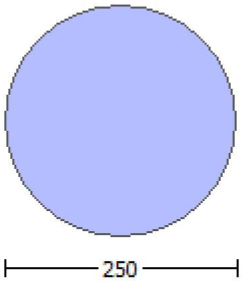
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

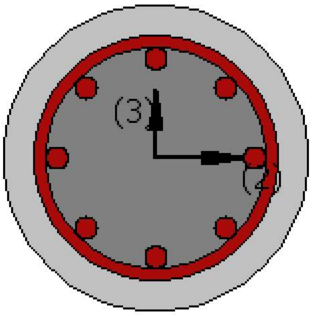
Analysis: Uniform +X

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 6.9705861E-031
EDGE -B-
Shear Force, Vb = -6.9705861E-031
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 4.9525674E-029
EDGE -B-
Shear Force, Vb = -4.9525674E-029
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00

lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00

Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Diameter, D = 250.00
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
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -7.8578E+007
Shear Force, V2 = -11112.547
Shear Force, V3 = 2.2804883E-011
Axial Force, F = -446381.238
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 763.407
-Compression: Aslc = 1272.345
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 0.09621333
θu = θy + θp = 0.09621333

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.071793 ((4.29),Biskinis Phd))
My = 8.7705E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 446381.238
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7705E+007
Φy ((10a) or (10b)) = 2.6387582E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.80035817
My_com (8b) = 8.7705E+007
Φ_com (7b) = 84.80871
error of function (7b) = -0.00559928
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60624026
N = 446381.238
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.02442033
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.32556294
d = 209.00
s = 150.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00826735
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 190.00
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 = 446381.238
Ag = 49087.385
f'cE = 15.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.041472
f'cE = 15.00

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

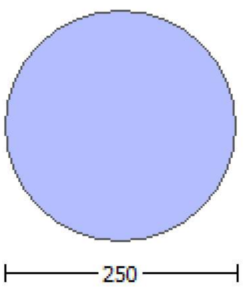
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

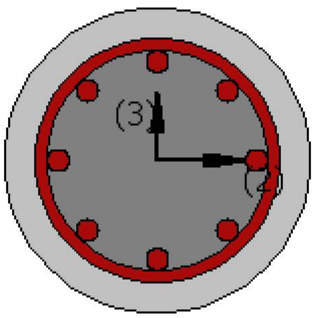
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
##
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -7.8578E+007
Shear Force, Va = -11112.547
EDGE -B-
Bending Moment, Mb = -2.2238E+006
Shear Force, Vb = 11112.547
BOTH EDGES
Axial Force, F = -446381.238
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 135681.32
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 135681.32
VCol = 146498.205
knl = 0.92616371
displacement_ductility_demand = 2.98448

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.2238E+006
Vu = 11112.547
d = 0.8*D = 200.00
Nu = 446381.238

Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85
bw*d = π*d*d/4 = 31415.927

---

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 = 0.01071325
θy = (My*Ls/3)/Eleff = 0.00358965 ((4.29),Biskinis Phd))
My = 8.7705E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 446381.238
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

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

---

My = Min(My_ten,My_com) = 8.7705E+007
Φy ((10a) or (10b)) = 2.6387582E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.80035817
My_com (8b) = 8.7705E+007
Φ_com (7b) = 84.80871
error of function (7b) = -0.00559928
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60624026
N = 446381.238
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

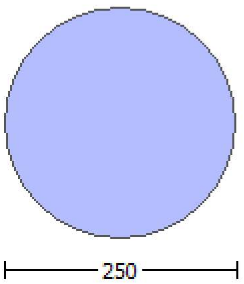
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

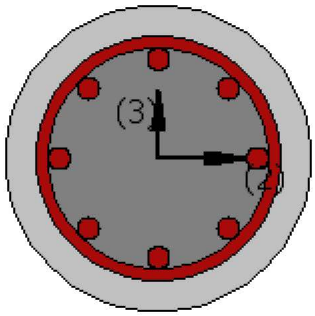
Analysis: Uniform +X

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 6.9705861E-031
EDGE -B-
Shear Force, Vb = -6.9705861E-031
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746

conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0682298E-009
Vu = 6.9705861E-031
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00

s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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 = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
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 = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.7465
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
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 4.9525674E-029
EDGE -B-
Shear Force, Vb = -4.9525674E-029
BOTH EDGES
Axial Force, F = -447004.162
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584

Calculation of Shear Capacity ratio , Ve/Vr = 0.32556294

Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 55813.539
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.3720E+007
Mu1+ = 8.3720E+007, 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- = 8.3720E+007, 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-) = 8.3720E+007
Mu2+ = 8.3720E+007, 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- = 8.3720E+007, 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 = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 8.3720E+007

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 36631.824
From 5A.2, TBDY: fcc = fc*λc = 26.19746
conf. factor λc = 1.7465
fc = 15.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 525.00
lb/ld = 1.00
d1 = 44.00
R = 125.00
v = 0.60624026
N = 447004.162
Ac = 49087.385
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 1.16122

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 171437.015

Calculation of Shear Strength at edge 1, Vr1 = 171437.015
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

Calculation of Shear Strength at edge 2, Vr2 = 171437.015
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 171437.015
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.5292626E-010
Vu = 4.9525674E-029
d = 0.8*D = 200.00
Nu = 447004.162
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 103630.846
Av = π/2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 80828.079
bw*d = π*d*d/4 = 31415.927

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 15.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Diameter, D = 250.00
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
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -8.7641823E-009
Shear Force, V2 = 11112.547
Shear Force, V3 = -2.2804883E-011
Axial Force, F = -446381.238
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 0.04236858
θu = θy + θp = 0.04236858

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01794825 ((4.29),Biskinis Phd))
My = 8.7705E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 446381.238
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7705E+007
Φy ((10a) or (10b)) = 2.6387582E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.80035817
My_com (8b) = 8.7705E+007
Φ_com (7b) = 84.80871

error of function (7b) = -0.00559928
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 125.00
v = 0.60624026
N = 446381.238
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.02442033
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.32556294
d = 209.00
s = 150.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00826735
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 190.00
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 = 446381.238
Ag = 49087.385
f'cE = 15.00
fytE = fylE = 420.00
pl = Area_Tot_Long_Rein/(Ag) = 0.041472
f'cE = 15.00

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

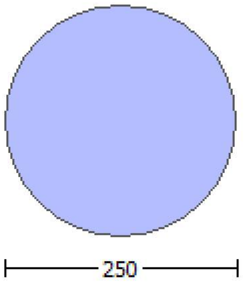
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

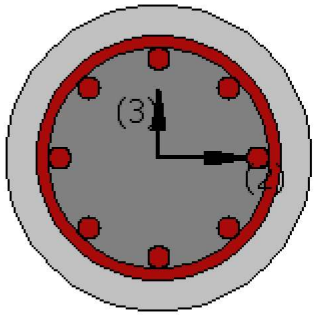
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
New material: Concrete Strength, fc = fcm = 15.00
New material: Steel Strength, fs = fsm = 420.00
##
Diameter, D = 250.00
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -7.2190302E-008
Shear Force, Va = 2.2804883E-011
EDGE -B-
Bending Moment, Mb = -8.7641823E-009
Shear Force, Vb = -2.2804883E-011
BOTH EDGES
Axial Force, F = -446381.238
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2035.752
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 678.584
-Compression: Asl,com = 678.584
-Middle: Asl,mid = 678.584
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 = 146498.205
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 146498.205
VCol = 146498.205
knl = 1.00
displacement_ductility_demand = 2.2204460E-016

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.7641823E-009
Vu = 2.2804883E-011
d = 0.8*D = 200.00
Nu = 446381.238
Ag = 49087.385
From (11.5.4.8), ACI 318-14: Vs = 98696.044
Av = π/2*A_stirrup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 65995.85
bw*d = π*d*d/4 = 31415.927

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 3.8172476E-018
θy = (My*Ls/3)/Eleff = 0.01794825 ((4.29),Biskinis Phd))
My = 8.7705E+007
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 = 2.4433E+012
factor = 0.70
Ag = 49087.385
fc' = 15.00
N = 446381.238
Ec*Ig = 3.4904E+012

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 8.7705E+007
Φy ((10a) or (10b)) = 2.6387582E-005
My_ten (8a) = 9.3578E+007
Φ_ten (7a) = 89.00
error of function (7a) = -0.80035817
My_com (8b) = 8.7705E+007
Φ_com (7b) = 84.80871
error of function (7b) = -0.00559928
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00

R = 125.00
v = 0.60624026
N = 446381.238
Ac = 49087.385
ω = 1.16122
with fc = 15.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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