Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

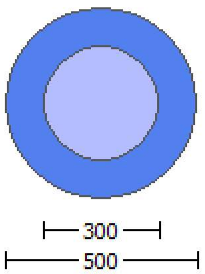
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

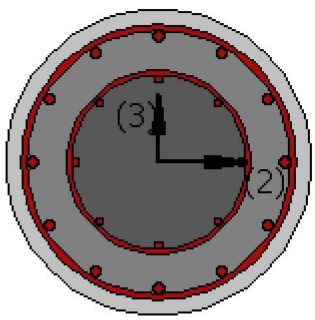
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4067E+007
Shear Force, Va = -4687.847
EDGE -B-
Bending Moment, Mb = 0.05009779
Shear Force, Vb = 4687.847
BOTH EDGES
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 334974.714
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 334974.714
VCol = 334974.714
knl = 1.00
displacement_ductility_demand = 0.02522788

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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.4067E+007

Vu = 4687.847
d = 0.8*D = 400.00
Nu = 7387.338
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

----
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 = 0.00016354
θy = (My*Ls/3)/Eleff = 0.00648247 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.769
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
  λ = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 625.00
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  ψt = 1.00
  ψs = 0.80
  ψe = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr = π/2 * Area of external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

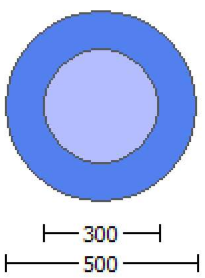
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

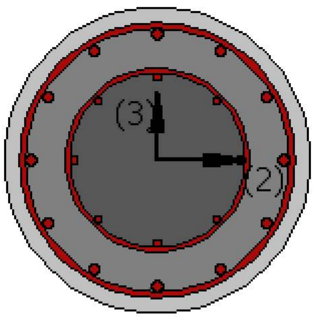
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135

lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60

with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487

φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 1.0499072E-009
Shear Force, V2 = -4687.847
Shear Force, V3 = -3.7842421E-013
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.0032404
θu = θy + θp = 0.0032404

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0032404 ((4.29),Biskinis Phd))

My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VColOE = 0.21168476
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428

jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where 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.
For the normalisation fs of jacket is used.
NUD = 7387.338
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

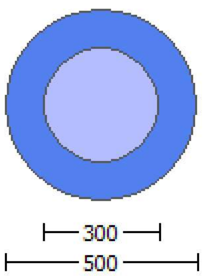
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

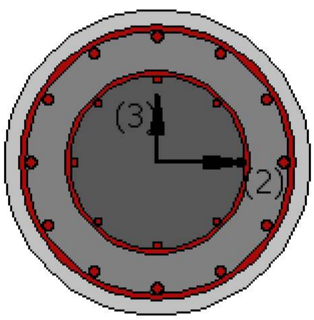
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.0499072E-009
Shear Force, Va = -3.7842421E-013
EDGE -B-
Bending Moment, Mb = 8.5635974E-011
Shear Force, Vb = 3.7842421E-013
BOTH EDGES
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 423209.318
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 423209.318
VCol = 423209.318
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0499072E-009
Vu = 3.7842421E-013
d = 0.8*D = 400.00
Nu = 7387.338
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

---

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.2277408E-020
θy = (My*Ls/3)/EIeff = 0.0032404 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

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

---

My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008

Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

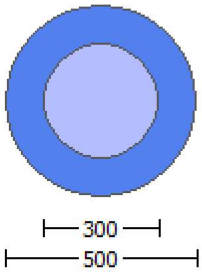
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

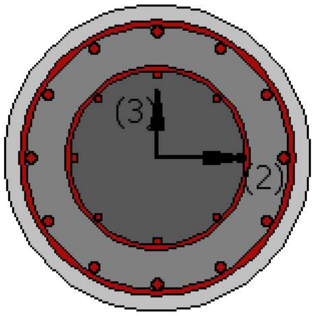
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701

s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00

R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80

ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055

fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-

Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514

From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1

db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030

d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.4067E+007
Shear Force, V2 = -4687.847
Shear Force, V3 = -3.7842421E-013
Axial Force, F = -7387.338

Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00648247
θu = θy + θp = 0.00648247

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00648247 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.769
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.21168476
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where 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.
For the normalisation fs of jacket is used.
NUD = 7387.338
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

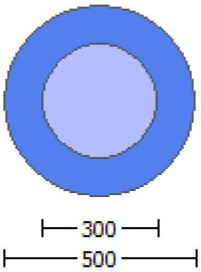
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

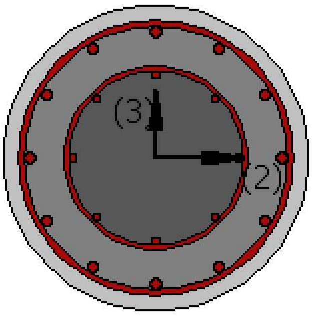
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel

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

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4067E+007
Shear Force, Va = -4687.847
EDGE -B-
Bending Moment, Mb = 0.05009779
Shear Force, Vb = 4687.847
BOTH EDGES
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 423209.318
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 423209.318
VCol = 423209.318
knl = 1.00
displacement_ductility_demand = 0.13740246

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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.05009779
Vu = 4687.847
d = 0.8*D = 400.00
Nu = 7387.338
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

----
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 = 8.9047878E-005
θy = (My*Ls/3)/Eleff = 0.00064808 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

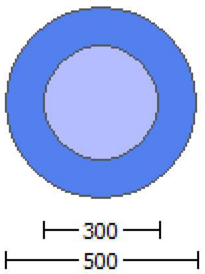
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

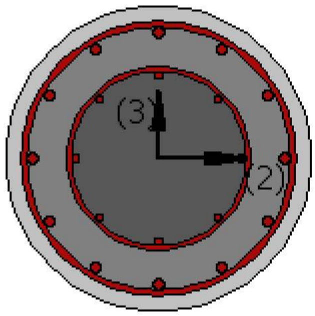
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00

Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393

N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135

lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663

bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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

Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696

fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487

φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835

fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 8.5635974E-011
Shear Force, V2 = 4687.847
Shear Force, V3 = 3.7842421E-013
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.0032404
θu = θy + θp = 0.0032404

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0032404 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002

apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.21168476
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where 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.
For the normalisation fs of jacket is used.
NUD = 7387.338
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

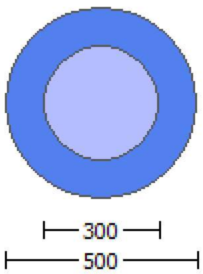
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

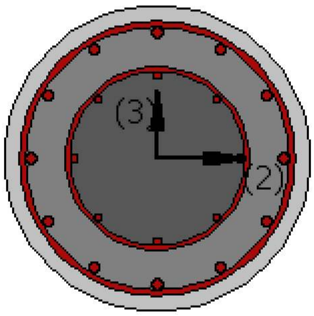
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.0499072E-009
Shear Force, Va = -3.7842421E-013
EDGE -B-
Bending Moment, Mb = 8.5635974E-011
Shear Force, Vb = 3.7842421E-013
BOTH EDGES
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 423209.318
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 423209.318
VCol = 423209.318
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5635974E-011
Vu = 3.7842421E-013
d = 0.8*D = 400.00
Nu = 7387.338
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00

s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

----
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 = 5.3141893E-021
θy = (My*Ls/3)/EIeff = 0.0032404 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3

MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

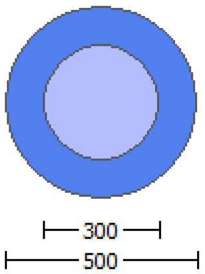
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

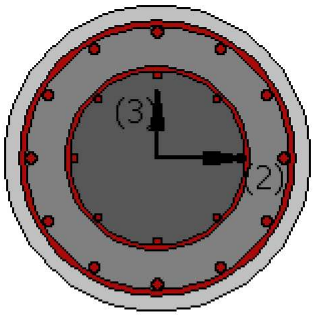
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00

Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393

N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

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

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3

Integration Section: (b)
Section Type: rcjcs

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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 0.05009779
Shear Force, V2 = 4687.847
Shear Force, V3 = 3.7842421E-013
Axial Force, F = -7387.338
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00064808
θu = θy + θp = 0.00064808

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00064808 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7387.338
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159581E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86209
error of function (7c) = 0.00290243
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27569
error of function (7d) = -0.00596423
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125411
N = 7387.338
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.21168476
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00

The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where 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.
For the normalisation fs of jacket is used.
NUD = 7387.338
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

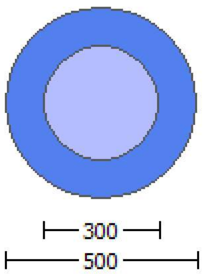
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

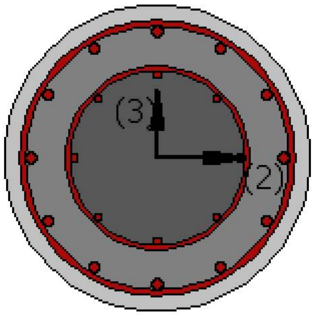
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.2226E+007
Shear Force, Va = -7406.71
EDGE -B-
Bending Moment, Mb = 0.07915355
Shear Force, Vb = 7406.71
BOTH EDGES
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 334974.606
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 334974.606
VCol = 334974.606
knl = 1.00
displacement_ductility_demand = 0.03985963

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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 2.2226E+007
Vu = 7406.71
d = 0.8*D = 400.00
Nu = 7386.251
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

----
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 = 0.00025839
θy = (My*Ls/3)/Eleff = 0.00648246 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.769
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324

with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

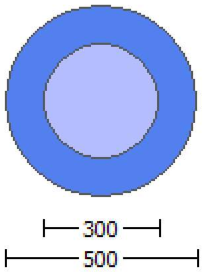
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

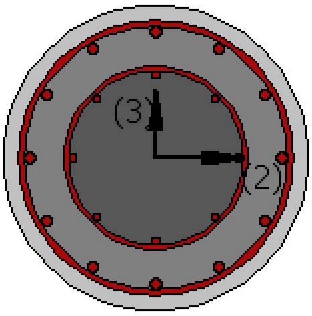
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60

with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487

φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00

s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 1.6470537E-009
Shear Force, V2 = -7406.71
Shear Force, V3 = -5.9790306E-013
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.03285837 θu = θy + θp = 0.03285837

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0032404 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

 - Calculation of θp -

From table 10-9: θp = 0.02961797

with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
 shear control ratio VyE/VCol0E = 0.21168476
 d = d_external = 0.00
 s = s_external = 0.00
 ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
 jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
 Av1 = 78.53982, is the area of stirrup
 Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
 s1 = 100.00
 core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
 Av2 = 50.26548, is the area of stirrup
 Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
 s2 = 250.00
 The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
 where 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.
 For the normalisation fs of jacket is used.
 NUD = 7386.251
 Ag = 196349.541
 f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
 fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
 fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
 f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

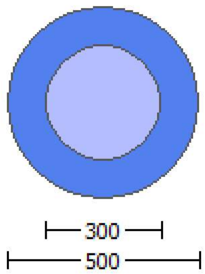
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

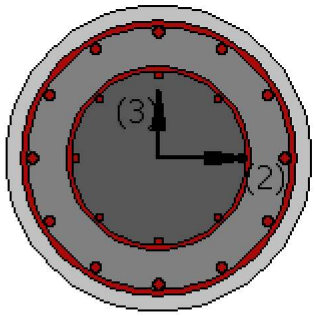
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.6470537E-009
Shear Force, Va = -5.9790306E-013
EDGE -B-
Bending Moment, Mb = 1.4708285E-010

Shear Force, Vb = 5.9790306E-013
BOTH EDGES
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 423209.102
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 423209.102
VCol = 423209.102
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6470537E-009
Vu = 5.9790306E-013
d = 0.8*D = 400.00
Nu = 7386.251
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.9398072E-020
θy = (My*Ls/3)/Eleff = 0.0032404 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

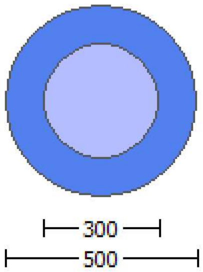
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

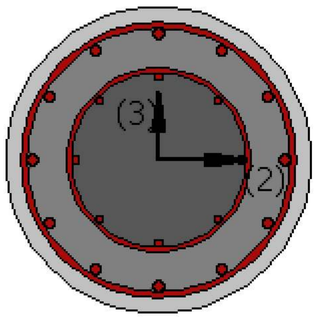
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00

No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00

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

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393

N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars

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

Stepwise Properties

Bending Moment, M = -2.2226E+007
Shear Force, V2 = -7406.71
Shear Force, V3 = -5.9790306E-013
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1272.345
-Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.03610043
θu = θy + θp = 0.03610043

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00648246 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.769
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.02961797
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.21168476
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where 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.
For the normalisation fs of jacket is used.
NUD = 7386.251
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

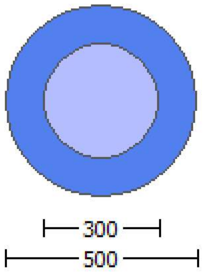
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

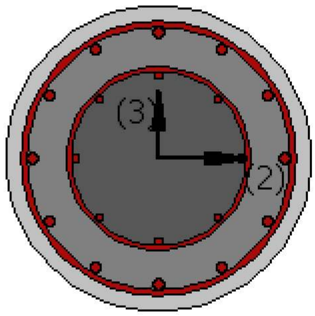
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
##

External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.2226E+007
Shear Force, Va = -7406.71
EDGE -B-
Bending Moment, Mb = 0.07915355
Shear Force, Vb = 7406.71
BOTH EDGES
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 423209.102
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 423209.102
VCol = 423209.102
knl = 1.00
displacement_ductility_demand = 0.21709356

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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.07915355
Vu = 7406.71
d = 0.8*D = 400.00
Nu = 7386.251
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

----
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 = 0.00014069
θy = (My*Ls/3)/EIeff = 0.00064808 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00

n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

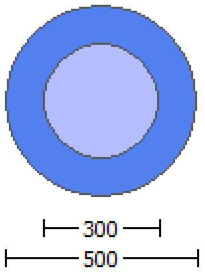
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

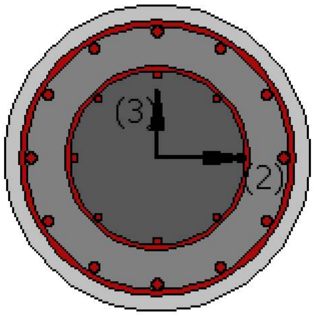
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884

conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:

Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

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

Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
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lb/ld = 0.12992616
d1 = 44.00
R = 250.00
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Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616

lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:

Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor, 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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 1.4708285E-010
Shear Force, V2 = 7406.71
Shear Force, V3 = 5.9790306E-013
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.03285837
θu = θy + θp = 0.03285837

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0032404 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008

Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.02961797
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.21168476
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where 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.
For the normalisation fs of jacket is used.
NUD = 7386.251
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein =

2.1219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

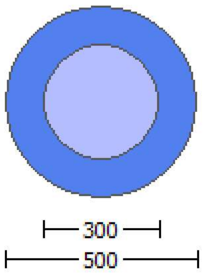
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

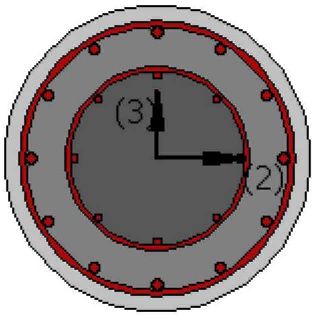
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjcs

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:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column

New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
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).
Jacket
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.6470537E-009
Shear Force, Va = -5.9790306E-013
EDGE -B-
Bending Moment, Mb = 1.4708285E-010
Shear Force, Vb = 5.9790306E-013
BOTH EDGES
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 423209.102
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 423209.102
VCol = 423209.102
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4708285E-010
Vu = 5.9790306E-013
d = 0.8*D = 400.00
Nu = 7386.251

Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 373328.906
bw*d = π*d*d/4 = 125663.706

----
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 = 8.3963180E-021
θy = (My*Ls/3)/Eleff = 0.0032404 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.3694E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00

ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

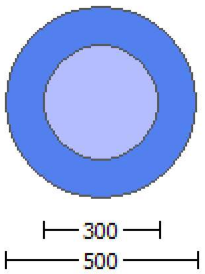
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

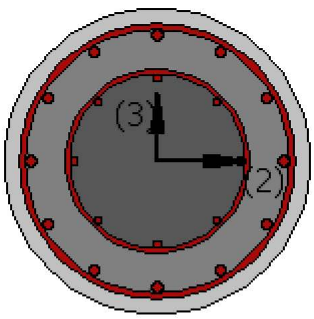
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.3940726E-031
EDGE -B-
Shear Force, Vb = -3.3940726E-031
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00

v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

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

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3

MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0310382E-011
Vu = 3.3940726E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 781.25
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.36696
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.5777218E-030
EDGE -B-
Shear Force, Vb = -1.5777218E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.21168476
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 110970.60
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6646E+008
Mu1+ = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction

which is defined for the static loading combination
Mu1- = 1.6646E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6646E+008
Mu2+ = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6646E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884

conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6646E+008

φ = 0.76794487
φ' = 0.68333426
error of function (3.68), Biskinis Phd = 48475.514
From 5A.2, TBDY: fcc = fc*λc = 41.00884
conf. factor λc = 1.36696
fc = 30.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 250.5135
lb/ld = 0.12992616
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.10389295

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.12992616
lb = 300.00
ld = 2309.004
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524225.731

Calculation of Shear Strength at edge 1, Vr1 = 524225.731
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 524225.731
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524225.731
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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6629350E-011
Vu = 1.5777218E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 308425.138
Vs1 = 308425.138 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 457232.663
bw*d = π*d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjcs

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:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 0.07915355
Shear Force, V2 = 7406.71
Shear Force, V3 = 5.9790306E-013
Axial Force, F = -7386.251
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.03026605
θu = θy + θp = 0.03026605

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00064808 ((4.29),Biskinis Phd))
My = 1.5355E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.3694E+013

factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00
N = 7386.251
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 7.8978E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5355E+008
Φy = 4.4159560E-006
My_ten (8c) = 1.5355E+008
Φ_ten (7c) = 64.86205
error of function (7c) = 0.00290247
My_com (8d) = 7.1091E+008
Φ_com (7d) = 65.27568
error of function (7d) = -0.00596425
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.003125
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00125393
N = 7386.251
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.324
with fc = 30.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.16240769
lb = 300.00
ld = 1847.203
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 625.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 4.11234
Atr = π/2 * Area of external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

- Calculation of θp -

From table 10-9: θp = 0.02961797
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.21168476
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading

(shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where 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.
For the normalisation fs of jacket is used.
NUD = 7386.251
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 30.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 30.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)
