Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

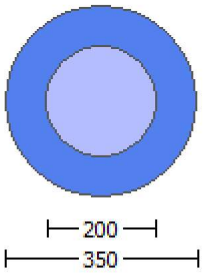
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

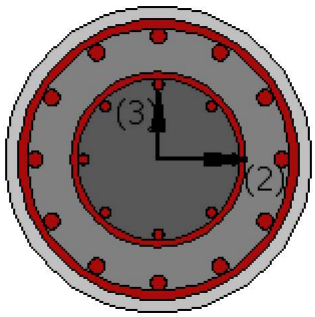
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column 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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -4.1102E+008
Shear Force, Va = -52898.623
EDGE -B-
Bending Moment, Mb = -1.0643E+007
Shear Force, Vb = 52898.623
BOTH EDGES
Axial Force, F = -1.9034E+006
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 = 316054.779
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 316054.779
VCol = 316054.779
knl = 1.00
displacement_ductility_demand = 1.14291

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.1102E+008

Vu = 52898.623
d = 0.8*D = 280.00
Nu = 1.9034E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
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 = 0.0460378
θy = (My*Ls/3)/EIeff = 0.04028106 ((4.29),Biskinis Phd))
My = 2.8039E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45694808
My_com (8b) = 2.8039E+008
Φ_com (7b) = 92.90019
error of function (7b) = -0.00414781
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.59949096
N = 1.9034E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

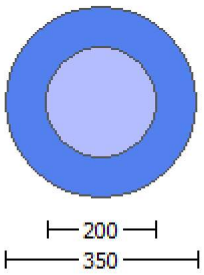
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

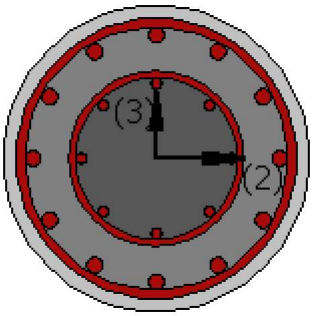
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367

conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275

ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.5297364E-009
Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835

fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.5297364E-009
Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044
EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00

d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56

s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 3.4281935E-006
Shear Force, V2 = -52898.623
Shear Force, V3 = 4.5420510E-010
Axial Force, F = -1.9034E+006
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 = 0.01215896
θu = θy + θp = 0.01215896

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01007027 ((4.29),Biskinis Phd))
My = 2.8039E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45694808

My_com (8b) = 2.8039E+008
Φ_com (7b) = 92.90019
error of function (7b) = -0.00414781
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.59949096
N = 1.9034E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.0020887
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.43494157
d = d_external = 209.00
s = s_external = 150.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9034E+006
Ag = 96211.275
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
f'cE = 33.00

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

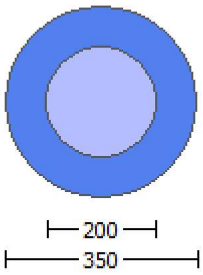
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

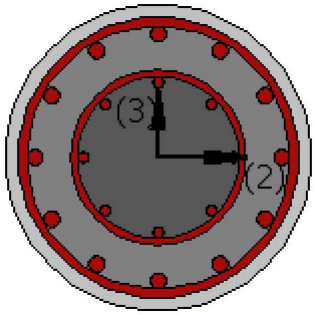
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column 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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##

External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 3.4281935E-006
Shear Force, Va = 4.5420510E-010
EDGE -B-
Bending Moment, Mb = -2.9052046E-006
Shear Force, Vb = -4.5420510E-010
BOTH EDGES
Axial Force, F = -1.9034E+006
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 = 459391.482
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 459391.482
VCol = 459391.482
knl = 1.00
displacement_ductility_demand = 3.2751579E-014

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.4281935E-006
Vu = 4.5420510E-010
d = 0.8*D = 280.00
Nu = 1.9034E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
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 = 3.2887142E-016
θy = (My*Ls/3)/EIeff = 0.01007027 ((4.29),Biskinis Phd))
My = 2.8039E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45694808
My_com (8b) = 2.8039E+008
Φ_com (7b) = 92.90019
error of function (7b) = -0.00414781
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.59949096
N = 1.9034E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

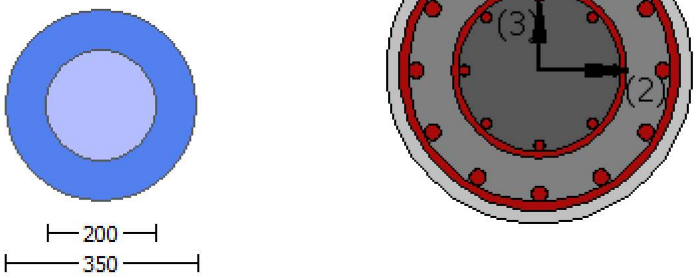
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)

No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334

φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009
    Vu = 5.0236177E-028
   d = 0.8*D = 280.00
   Nu = 1.9073E+006
   Ag = 96211.275
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
   Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
   Vs1 is multiplied by αCol1 = 1.00
    s/d = 0.35714286
   Vs2 = 0.00 is calculated for core, with:
    Av = π/2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
   Vs2 is multiplied by αCol2 = 0.00
    s/d = 1.5625
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 234979.335
    bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.5297364E-009
Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member

Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044
EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68

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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -4.1102E+008
Shear Force, V2 = -52898.623
Shear Force, V3 = 4.5420510E-010
Axial Force, F = -1.9034E+006
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 = 0.04236976
θu = θy + θp = 0.04236976

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.04028106 ((4.29),Biskinis Phd))
My = 2.8039E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45694808
My_com (8b) = 2.8039E+008
Φ_com (7b) = 92.90019
error of function (7b) = -0.00414781
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.59949096
N = 1.9034E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

 - Calculation of θp -

From table 10-9: θp = 0.0020887
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 0.43494157
  d = d_external = 209.00
  s = s_external = 150.00
  ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
  jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508
      Av1 = 78.53982, is the area of stirrup
      Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
      s1 = 100.00
  core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
      Av2 = 50.26548, is the area of stirrup
      Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9034E+006
   Ag = 96211.275
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
   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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
   f'cE = 33.00

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

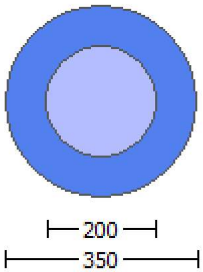
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

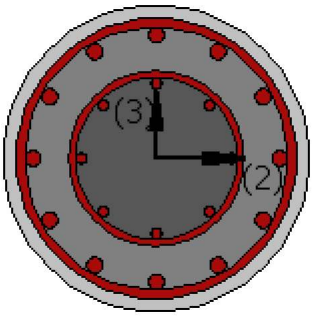
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column 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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -4.1102E+008
Shear Force, Va = -52898.623
EDGE -B-
Bending Moment, Mb = -1.0643E+007

Shear Force, Vb = 52898.623
BOTH EDGES
Axial Force, F = -1.9034E+006
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 = 359212.198
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 359212.198
VCol = 459391.482
knl = 0.78193047
displacement_ductility_demand = 4.90759

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0643E+007
Vu = 52898.623
d = 0.8*D = 280.00
Nu = 1.9034E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
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 = 0.00988415
θy = (My*Ls/3)/EIeff = 0.00201405 ((4.29),Biskinis Phd))
My = 2.8039E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
  My_ten (8a) = 3.1367E+008
  Φ_ten (7a) = 89.00
  error of function (7a) = -0.45694808
  My_com (8b) = 2.8039E+008
  Φ_com (7b) = 92.90019
  error of function (7b) = -0.00414781
    with ey = 0.0027778
        eco = 0.002
        apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
        d1 = 34.00
        R = 175.00
        v = 0.59949096
        N = 1.9034E+006
        Ac = 96211.275
        ω = 0.53432709
 with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

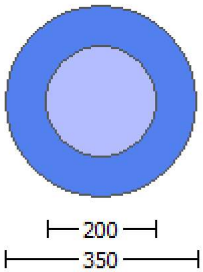
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

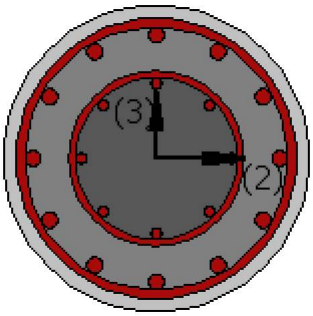
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708

fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009
    Vu = 5.0236177E-028
   d = 0.8*D = 280.00
   Nu = 1.9073E+006
   Ag = 96211.275
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
   Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
   Vs1 is multiplied by αCol1 = 1.00
    s/d = 0.35714286
   Vs2 = 0.00 is calculated for core, with:
    Av = π/2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
   Vs2 is multiplied by αCol2 = 0.00
    s/d = 1.5625
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 234979.335
    bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009
    Vu = 5.0236177E-028
   d = 0.8*D = 280.00
   Nu = 1.9073E+006
   Ag = 96211.275
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
   Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56

s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044

EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00

R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006

Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.9052046E-006
Shear Force, V2 = 52898.623
Shear Force, V3 = -4.5420510E-010
Axial Force, F = -1.9034E+006
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 = 0.01215896
θu = θy + θp = 0.01215896

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01007027 ((4.29),Biskinis Phd))
My = 2.8039E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45694808
My_com (8b) = 2.8039E+008
Φ_com (7b) = 92.90019
error of function (7b) = -0.00414781
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.59949096
N = 1.9034E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.0020887
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 0.43494157
d = d_external = 209.00
s = s_external = 150.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508

Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9034E+006
Ag = 96211.275
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
f'cE = 33.00

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

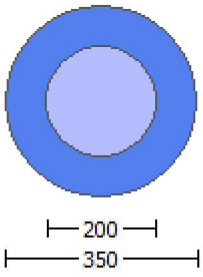
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

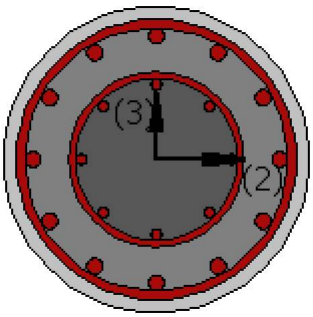
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column 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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 3.4281935E-006
Shear Force, Va = 4.5420510E-010
EDGE -B-
Bending Moment, Mb = -2.9052046E-006
Shear Force, Vb = -4.5420510E-010
BOTH EDGES
Axial Force, F = -1.9034E+006
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 = 459391.482

Vn ((10.3), ASCE 41-17) = knl*VCol0 = 459391.482
VCol = 459391.482
knl = 1.00
displacement_ductility_demand = 2.1205260E-014

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.9052046E-006
Vu = 4.5420510E-010
d = 0.8*D = 280.00
Nu = 1.9034E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.1420999E-016
θy = (My*Ls/3)/EIeff = 0.01007027 ((4.29),Biskinis Phd))
My = 2.8039E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45694808
My_com (8b) = 2.8039E+008
Φ_com (7b) = 92.90019
error of function (7b) = -0.00414781
with ey = 0.0027778

eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.59949096
N = 1.9034E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

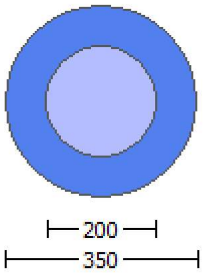
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

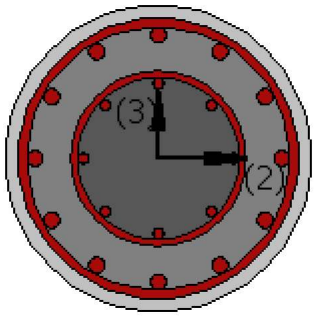
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009

Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.5297364E-009
Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044
EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.0643E+007
Shear Force, V2 = 52898.623
Shear Force, V3 = -4.5420510E-010
Axial Force, F = -1.9034E+006
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 = 0.00410275
θu = θy + θp = 0.00410275

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00201405 ((4.29),Biskinis Phd))
My = 2.8039E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9034E+006

Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8039E+008
Φy ((10a) or (10b)) = 1.6317264E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45694808
My_com (8b) = 2.8039E+008
Φ_com (7b) = 92.90019
error of function (7b) = -0.00414781
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.59949096
N = 1.9034E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.0020887
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.43494157
d = d_external = 209.00
s = s_external = 150.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9034E+006
Ag = 96211.275
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
f'cE = 33.00

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

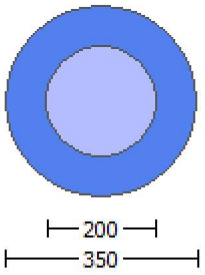
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

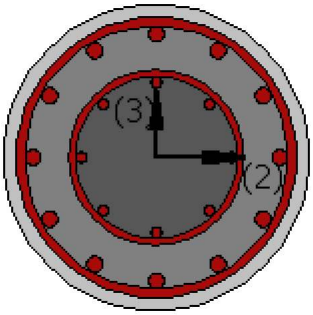
Analysis: Uniform +X

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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -3.2695E+008
Shear Force, Va = -57482.021
EDGE -B-
Bending Moment, Mb = -1.1547E+007
Shear Force, Vb = 57482.021
BOTH EDGES
Axial Force, F = -1.9049E+006
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 = 316106.611
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 316106.611
VCol = 316106.611
knl = 1.00
displacement_ductility_demand = 0.76156446

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.2695E+008
Vu = 57482.021
d = 0.8*D = 280.00
Nu = 1.9049E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
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 = 0.02907545
θy = (My*Ls/3)/EIeff = 0.03817858 ((4.29),Biskinis Phd))
My = 2.8034E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 5687.826
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45743633
My_com (8b) = 2.8034E+008
Φ_com (7b) = 92.92419
error of function (7b) = -0.00415979
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9049E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

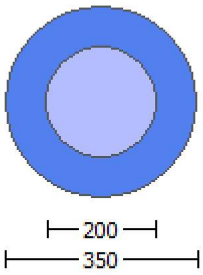
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

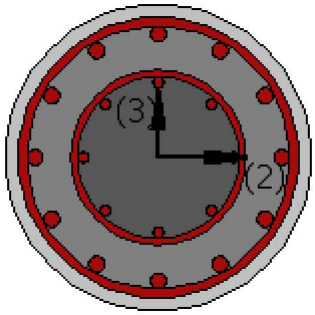
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708

Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009
    Vu = 5.0236177E-028
  d = 0.8*D = 280.00
  Nu = 1.9073E+006
  Ag = 96211.275
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
  Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by αCol1 = 1.00
    s/d = 0.35714286
  Vs2 = 0.00 is calculated for core, with:
    Av = π/2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by αCol2 = 0.00
    s/d = 1.5625
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 234979.335
    bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.5297364E-009
Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45

##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044
EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00

R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 4.7732016E-009
    Vu = 3.0759771E-044
  d = 0.8*D = 280.00
  Nu = 1.9073E+006
  Ag = 96211.275
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
  Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by αCol1 = 1.00
    s/d = 0.35714286
  Vs2 = 0.00 is calculated for core, with:
    Av = π/2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by αCol2 = 0.00
    s/d = 1.5625
  Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00

Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 3.7463780E-006
Shear Force, V2 = -57482.021
Shear Force, V3 = 1.5797676E-010
Axial Force, F = -1.9049E+006
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 = 0.02398936
θu = θy + θp = 0.02398936

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0100685 ((4.29),Biskinis Phd))
My = 2.8034E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45743633
My_com (8b) = 2.8034E+008
Φ_com (7b) = 92.92419
error of function (7b) = -0.00415979
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9049E+006

Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.01392087
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.43494157
d = d_external = 209.00
s = s_external = 150.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9049E+006
Ag = 96211.275
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
f'cE = 33.00

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

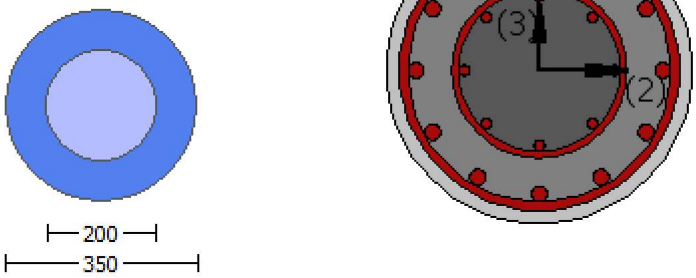
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 3.7463780E-006
Shear Force, Va = 1.5797676E-010
EDGE -B-
Bending Moment, Mb = -2.5850040E-006
Shear Force, Vb = -1.5797676E-010
BOTH EDGES
Axial Force, F = -1.9049E+006
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 = 459495.145
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 459495.145
VCol = 459495.145
knl = 1.00
displacement_ductility_demand = 2.8421709E-014

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.7463780E-006
Vu = 1.5797676E-010
d = 0.8*D = 280.00
Nu = 1.9049E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.8545137E-016
θy = (My*Ls/3)/EIeff = 0.0100685 ((4.29),Biskinis Phd))
My = 2.8034E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45743633
My_com (8b) = 2.8034E+008
Φ_com (7b) = 92.92419
error of function (7b) = -0.00415979
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9049E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

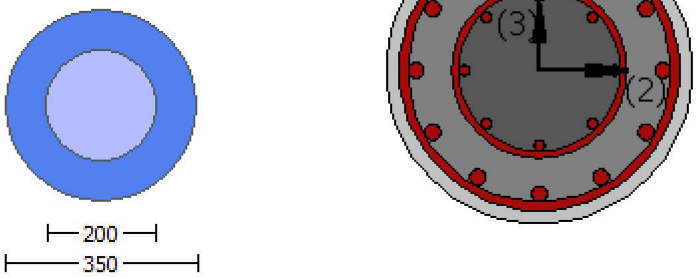
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)

No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334

φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009
    Vu = 5.0236177E-028
   d = 0.8*D = 280.00
   Nu = 1.9073E+006
   Ag = 96211.275
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
   Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
   Vs1 is multiplied by αCol1 = 1.00
    s/d = 0.35714286
   Vs2 = 0.00 is calculated for core, with:
    Av = π/2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
   Vs2 is multiplied by αCol2 = 0.00
    s/d = 1.5625
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 234979.335
    bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.5297364E-009
Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member

Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044
EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 4.7732016E-009
    Vu = 3.0759771E-044
   d = 0.8*D = 280.00
   Nu = 1.9073E+006
   Ag = 96211.275
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
   Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
   Vs1 is multiplied by αCol1 = 1.00
    s/d = 0.35714286
   Vs2 = 0.00 is calculated for core, with:
    Av = π/2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
   Vs2 is multiplied by αCol2 = 0.00
    s/d = 1.5625
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 234979.335
    bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68

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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -3.2695E+008
Shear Force, V2 = -57482.021
Shear Force, V3 = 1.5797676E-010
Axial Force, F = -1.9049E+006
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 = 0.05209945
θu = θy + θp = 0.05209945

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.03817858 ((4.29),Biskinis Phd))
My = 2.8034E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 5687.826
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45743633
My_com (8b) = 2.8034E+008
Φ_com (7b) = 92.92419
error of function (7b) = -0.00415979
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9049E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

 - Calculation of θp -

From table 10-9: θp = 0.01392087
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 0.43494157
  d = d_external = 209.00
  s = s_external = 150.00
  ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
  jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508
      Av1 = 78.53982, is the area of stirrup
      Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
      s1 = 100.00
  core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
      Av2 = 50.26548, is the area of stirrup
      Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9049E+006
   Ag = 96211.275
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
   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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
   f'cE = 33.00

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

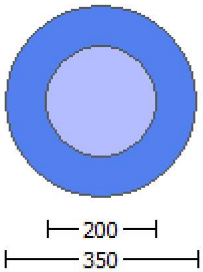
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

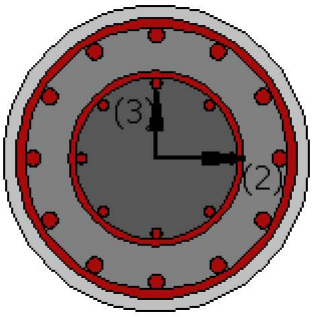
Analysis: Uniform +X

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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -3.2695E+008
Shear Force, Va = -57482.021
EDGE -B-
Bending Moment, Mb = -1.1547E+007

Shear Force, Vb = 57482.021
BOTH EDGES
Axial Force, F = -1.9049E+006
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 = 395966.231
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 395966.231
VCol = 459495.145
knl = 0.86174192
displacement_ductility_demand = 3.84344

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1547E+007
Vu = 57482.021
d = 0.8*D = 280.00
Nu = 1.9049E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
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 = 0.00773954
θy = (My*Ls/3)/EIeff = 0.0020137 ((4.29),Biskinis Phd))
My = 2.8034E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
  My_ten (8a) = 3.1367E+008
  Φ_ten (7a) = 89.00
  error of function (7a) = -0.45743633
  My_com (8b) = 2.8034E+008
  Φ_com (7b) = 92.92419
  error of function (7b) = -0.00415979
    with ey = 0.0027778
        eco = 0.002
        apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
        d1 = 34.00
        R = 175.00
        v = 0.5999792
        N = 1.9049E+006
        Ac = 96211.275
        ω = 0.53432709
 with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

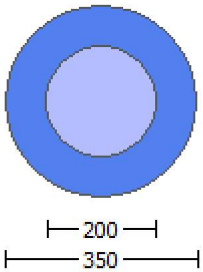
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

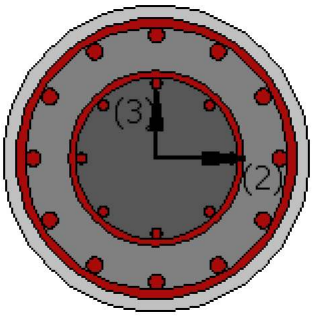
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708

fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009
    Vu = 5.0236177E-028
  d = 0.8*D = 280.00
  Nu = 1.9073E+006
  Ag = 96211.275
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
  Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by αCol1 = 1.00
    s/d = 0.35714286
  Vs2 = 0.00 is calculated for core, with:
    Av = π/2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by αCol2 = 0.00
    s/d = 1.5625
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 234979.335
    bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009
    Vu = 5.0236177E-028
  d = 0.8*D = 280.00
  Nu = 1.9073E+006
  Ag = 96211.275
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
  Vs1 = 191910.51 is calculated for jacket, with:
    Av = π/2*A_stirrup = 123370.055
    fy = 555.56

s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044

EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00

R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006

Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.5850040E-006
Shear Force, V2 = 57482.021
Shear Force, V3 = -1.5797676E-010
Axial Force, F = -1.9049E+006
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 = 0.02398936
θu = θy + θp = 0.02398936

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0100685 ((4.29),Biskinis Phd))
My = 2.8034E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45743633
My_com (8b) = 2.8034E+008
Φ_com (7b) = 92.92419
error of function (7b) = -0.00415979
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9049E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.01392087
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.43494157
d = d_external = 209.00
s = s_external = 150.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508

Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9049E+006
Ag = 96211.275
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
f'cE = 33.00

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

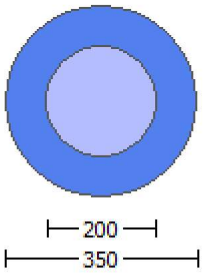
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

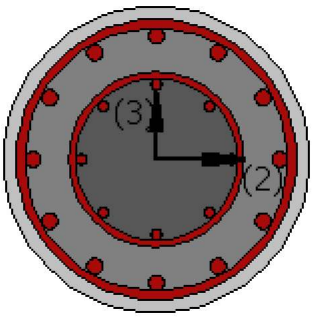
Analysis: Uniform +X

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 = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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 = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 3.7463780E-006
Shear Force, Va = 1.5797676E-010
EDGE -B-
Bending Moment, Mb = -2.5850040E-006
Shear Force, Vb = -1.5797676E-010
BOTH EDGES
Axial Force, F = -1.9049E+006
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 = 459495.145

Vn ((10.3), ASCE 41-17) = knl*VCol0 = 459495.145
VCol = 459495.145
knl = 1.00
displacement_ductility_demand = 2.0650148E-014

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.5850040E-006
Vu = 1.5797676E-010
d = 0.8*D = 280.00
Nu = 1.9049E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 172718.077
Vs1 = 172718.077 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 = 0.35714286
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 = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 204523.259
bw*d = π*d*d/4 = 61575.216

---
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.0865396E-016
θy = (My*Ls/3)/EIeff = 0.0100685 ((4.29),Biskinis Phd))
My = 2.8034E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45743633
My_com (8b) = 2.8034E+008
Φ_com (7b) = 92.92419
error of function (7b) = -0.00415979
with ey = 0.0027778

eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9049E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

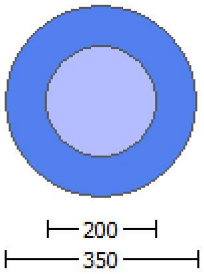
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

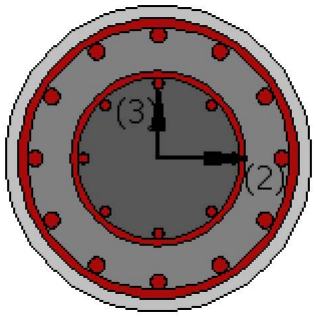
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 5.0236177E-028
EDGE -B-
Shear Force, Vb = -5.0236177E-028
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 5.5297364E-009

Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.5297364E-009
Vu = 5.0236177E-028
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Mean Confinement Factor overall section = 1.38708
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -3.0759771E-044
EDGE -B-
Shear Force, Vb = 3.0759771E-044
BOTH EDGES
Axial Force, F = -1.9073E+006
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 = 0.43494157
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 218348.36
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.2752E+008
Mu1+ = 3.2752E+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- = 3.2752E+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-) = 3.2752E+008
Mu2+ = 3.2752E+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- = 3.2752E+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 = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
conf. factor λc = 1.38708
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
lb/ld = 1.00
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9073E+006
Ac = 96211.275
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 3.2752E+008

φ = 1.55334
φ' = 1.35517
error of function (3.68), Biskinis Phd = 484850.706
From 5A.2, TBDY: fcc = fc*λc = 45.77367
  conf. factor λc = 1.38708
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 694.45
    lb/ld = 1.00
    d1 = 34.00
    R = 175.00
    v = 0.5999792
      N = 1.9073E+006
      Ac = 96211.275
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.53432709

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 502017.68

Calculation of Shear Strength at edge 1, Vr1 = 502017.68
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 502017.68
  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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

Calculation of Shear Strength at edge 2, Vr2 = 502017.68
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 502017.68
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 = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.7732016E-009
Vu = 3.0759771E-044
d = 0.8*D = 280.00
Nu = 1.9073E+006
Ag = 96211.275
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 191910.51
Vs1 = 191910.51 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.35714286
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 555.56
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 234979.335
bw*d = π*d*d/4 = 61575.216

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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 350.00
Internal Diameter, D = 200.00
Cover Thickness, c = 15.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.1547E+007
Shear Force, V2 = 57482.021
Shear Force, V3 = -1.5797676E-010
Axial Force, F = -1.9049E+006
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 = 0.01593457
θu = θy + θp = 0.01593457

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0020137 ((4.29),Biskinis Phd))
My = 2.8034E+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 = 1.3922E+013
factor = 0.70
Ag = 96211.275
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 1.9049E+006

Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 1.9888E+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) = 2.8034E+008
Φy ((10a) or (10b)) = 1.6310770E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.45743633
My_com (8b) = 2.8034E+008
Φ_com (7b) = 92.92419
error of function (7b) = -0.00415979
with ey = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 34.00
R = 175.00
v = 0.5999792
N = 1.9049E+006
Ac = 96211.275
ω = 0.53432709
with fc = 33.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-9: θp = 0.01392087
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.43494157
d = d_external = 209.00
s = s_external = 150.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00460534
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.00397508
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 310.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00063027
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 192.00, 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 = 1.9049E+006
Ag = 96211.275
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
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 = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.03173878
f'cE = 33.00

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

At local axis: 3
Integration Section: (b)