Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

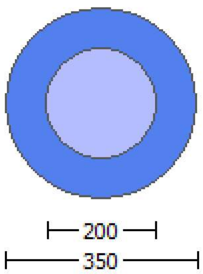
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

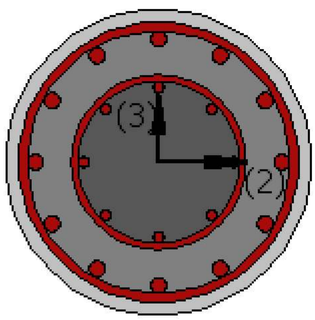
Analysis: Uniform +X

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 = -4.3336E+008
Shear Force, Va = -24353.36
EDGE -B-
Bending Moment, Mb = -4.9667E+006
Shear Force, Vb = 24353.36
BOTH EDGES
Axial Force, F = -2.3769E+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 = 331101.682
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 331101.682
VCol = 331101.682
knl = 1.00
displacement_ductility_demand = 1.34528

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 = 4.3336E+008

Vu = 24353.36
d = 0.8*D = 280.00
Nu = 2.3769E+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 = 0.05122256
θy = (My*Ls/3)/Eleff = 0.03807568 ((4.29),Biskinis Phd))
My = 2.6504E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962
My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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

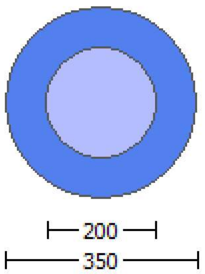
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

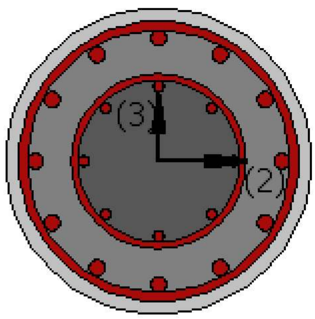
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045
EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 7.3814362E-005
Shear Force, V2 = -24353.36
Shear Force, V3 = 2.6276416E-010
Axial Force, F = -2.3769E+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 = 0.01040986
θu = θy + θp = 0.01040986

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00951892 ((4.29),Biskinis Phd))
My = 2.6504E+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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962

My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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 = 0.00089094
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.40888624
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 = 2.3769E+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

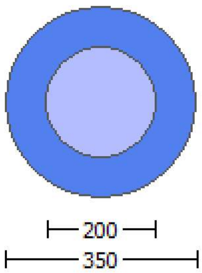
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

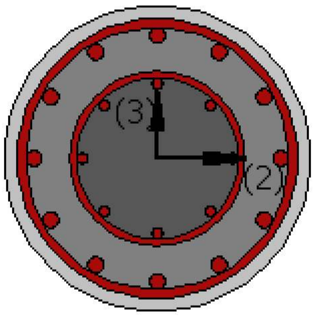
Analysis: Uniform +X

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 = 7.3814362E-005
Shear Force, Va = 2.6276416E-010
EDGE -B-
Bending Moment, Mb = -1.2947145E-005
Shear Force, Vb = -2.6276416E-010
BOTH EDGES
Axial Force, F = -2.3769E+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 = 489485.286
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 489485.286
VCol = 489485.286
knl = 1.00
displacement_ductility_demand = 9.0860652E-013

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 = 7.3814362E-005
Vu = 2.6276416E-010
d = 0.8*D = 280.00
Nu = 2.3769E+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 = 8.6488661E-015
θy = (My*Ls/3)/EIeff = 0.00951892 ((4.29),Biskinis Phd))
My = 2.6504E+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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962
My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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

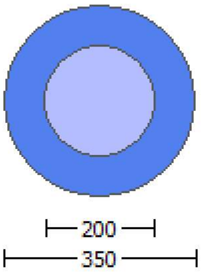
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

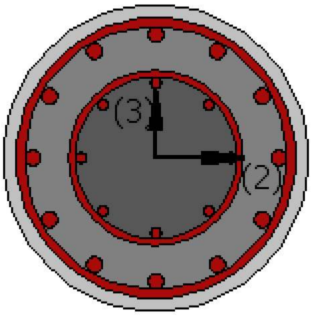
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045
EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60

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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -4.3336E+008
Shear Force, V2 = -24353.36
Shear Force, V3 = 2.6276416E-010
Axial Force, F = -2.3769E+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 = 0.03896662
θu = θy + θp = 0.03896662

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.03807568 ((4.29),Biskinis Phd))
My = 2.6504E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962
My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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 = 0.00089094
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VCol0E = 0.40888624
   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 = 2.3769E+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

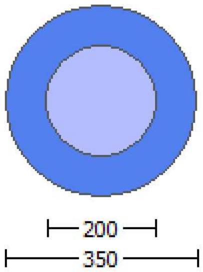
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

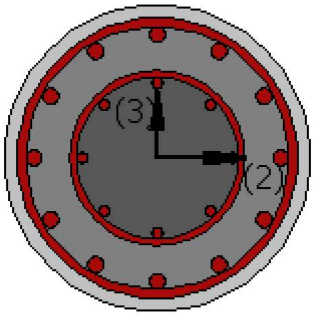
Analysis: Uniform +X

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 = -4.3336E+008
Shear Force, Va = -24353.36
EDGE -B-
Bending Moment, Mb = -4.9667E+006

Shear Force, Vb = 24353.36
BOTH EDGES
Axial Force, F = -2.3769E+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 = 357478.252
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 357478.252
VCol = 489485.286
knl = 0.7303146
displacement_ductility_demand = 5.59581

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 = 4.9667E+006
Vu = 24353.36
d = 0.8*D = 280.00
Nu = 2.3769E+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 = 0.0106532
θy = (My*Ls/3)/EIeff = 0.00190378 ((4.29),Biskinis Phd))
My = 2.6504E+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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962
My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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

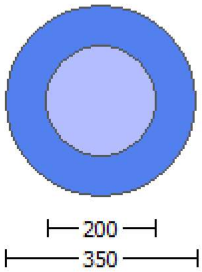
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

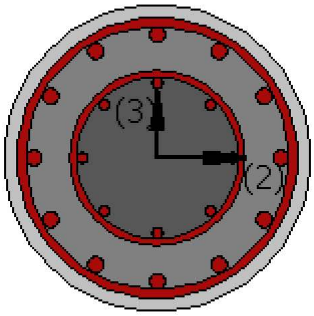
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045

EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -1.2947145E-005
Shear Force, V2 = 24353.36
Shear Force, V3 = -2.6276416E-010
Axial Force, F = -2.3769E+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 = 0.01040986
θu = θy + θp = 0.01040986

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00951892 ((4.29),Biskinis Phd))
My = 2.6504E+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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962
My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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 = 0.00089094
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.40888624
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 = 2.3769E+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

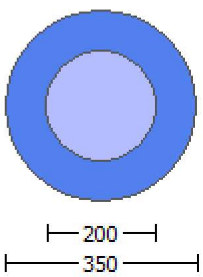
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

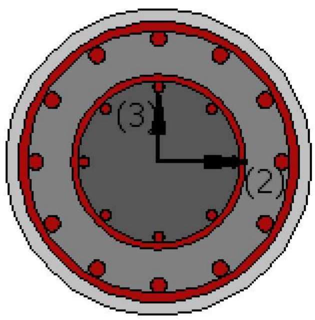
Analysis: Uniform +X

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 = 7.3814362E-005
Shear Force, Va = 2.6276416E-010
EDGE -B-
Bending Moment, Mb = -1.2947145E-005
Shear Force, Vb = -2.6276416E-010
BOTH EDGES
Axial Force, F = -2.3769E+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 = 489485.286

Vn ((10.3), ASCE 41-17) = knl*VCol0 = 489485.286
VCol = 489485.286
knl = 1.00
displacement_ductility_demand = 6.1362804E-011

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 = 1.2947145E-005
Vu = 2.6276416E-010
d = 0.8*D = 280.00
Nu = 2.3769E+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 = 5.8410746E-013
θy = (My*Ls/3)/EIeff = 0.00951892 ((4.29),Biskinis Phd))
My = 2.6504E+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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962
My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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

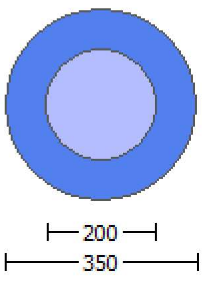
Limit State: Immediate Occupancy (data interpolation between analysis steps 50 and 51)

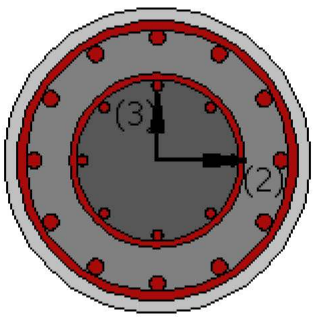
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009

Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045
EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -4.9667E+006
Shear Force, V2 = 24353.36
Shear Force, V3 = -2.6276416E-010
Axial Force, F = -2.3769E+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 = 0.00279472
θu = θy + θp = 0.00279472

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00190378 ((4.29),Biskinis Phd))
My = 2.6504E+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 = 2.3769E+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) = 2.6504E+008
Φy ((10a) or (10b)) = 1.4461825E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60609962
My_com (8b) = 2.6504E+008
Φ_com (7b) = 100.6837
error of function (7b) = -0.00912485
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 = 0.7486425
N = 2.3769E+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 = 0.00089094
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.40888624
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 = 2.3769E+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

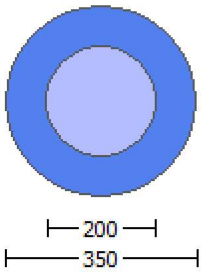
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

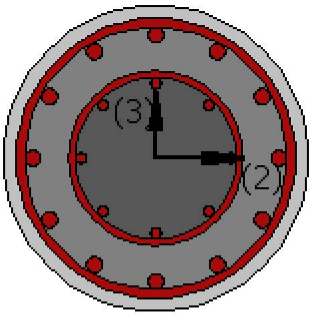
Analysis: Uniform +X

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 = -3.3955E+008
Shear Force, Va = -38921.202
EDGE -B-
Bending Moment, Mb = -7.8578E+006
Shear Force, Vb = 38921.202
BOTH EDGES
Axial Force, F = -2.3784E+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 = 331147.64
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 331147.64
VCol = 331147.64
knl = 1.00
displacement_ductility_demand = 0.84977309

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 = 3.3955E+008
Vu = 38921.202
d = 0.8*D = 280.00
Nu = 2.3784E+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 = 0.03234948
θy = (My*Ls/3)/EIeff = 0.03806837 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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

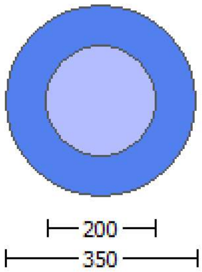
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

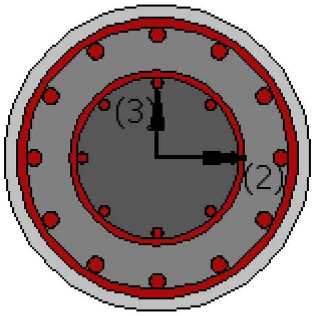
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706

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 = 0.74912084

N = 2.3809E+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 = 958400.706

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 = 0.74912084

N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045
EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 5.5509321E-005
Shear Force, V2 = -38921.202
Shear Force, V3 = 1.0433598E-010
Axial Force, F = -2.3784E+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 = 0.01365473
θu = θy + θp = 0.01365473

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00951709 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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 = 0.00413763
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.40888624
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 = 2.3784E+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

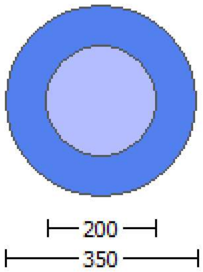
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

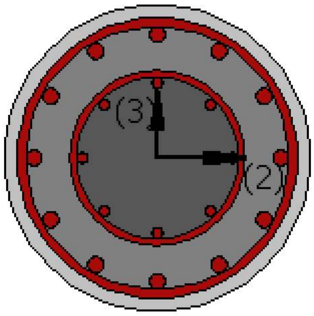
Analysis: Uniform +X

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 = 5.5509321E-005
Shear Force, Va = 1.0433598E-010
EDGE -B-
Bending Moment, Mb = -1.2679769E-005
Shear Force, Vb = -1.0433598E-010
BOTH EDGES
Axial Force, F = -2.3784E+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 = 489577.202
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 489577.202
VCol = 489577.202
knl = 1.00
displacement_ductility_demand = 6.3593575E-013

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 = 5.5509321E-005
Vu = 1.0433598E-010
d = 0.8*D = 280.00
Nu = 2.3784E+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 = 6.0517541E-015
θy = (My*Ls/3)/EIeff = 0.00951709 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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

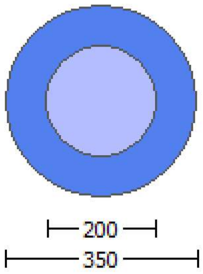
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

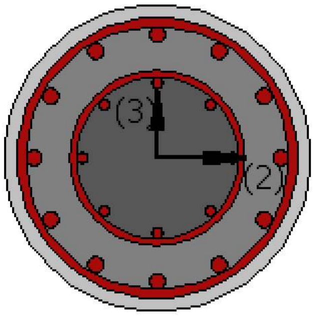
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045
EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60

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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -3.3955E+008
Shear Force, V2 = -38921.202
Shear Force, V3 = 1.0433598E-010
Axial Force, F = -2.3784E+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 = 0.042206
θu = θy + θp = 0.042206

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.03806837 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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 = 0.00413763
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VCol0E = 0.40888624
   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 = 2.3784E+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

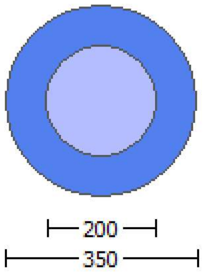
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

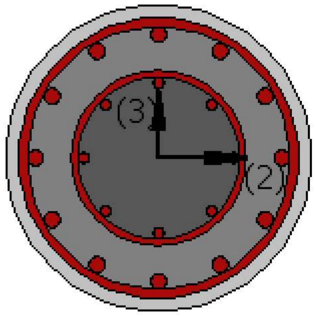
Analysis: Uniform +X

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 = -3.3955E+008
Shear Force, Va = -38921.202
EDGE -B-
Bending Moment, Mb = -7.8578E+006

Shear Force, Vb = 38921.202
BOTH EDGES
Axial Force, F = -2.3784E+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 = 404978.234
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 404978.234
VCol = 489577.202
knl = 0.82719994
displacement_ductility_demand = 4.304

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 = 7.8578E+006
Vu = 38921.202
d = 0.8*D = 280.00
Nu = 2.3784E+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 = 0.00819231
θy = (My*Ls/3)/EIeff = 0.00190342 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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

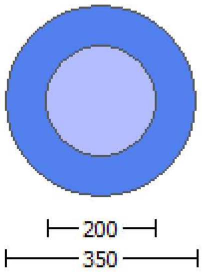
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

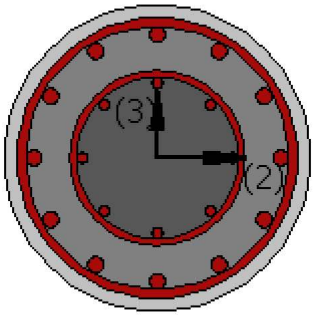
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045

EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -1.2679769E-005
Shear Force, V2 = 38921.202
Shear Force, V3 = -1.0433598E-010
Axial Force, F = -2.3784E+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 = 0.01365473
θu = θy + θp = 0.01365473

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00951709 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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 = 0.00413763
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.40888624
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 = 2.3784E+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

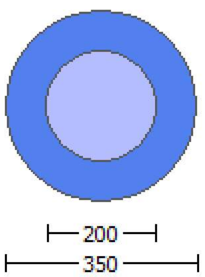
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

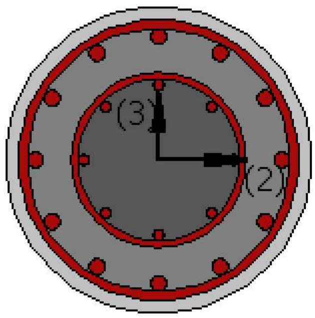
Analysis: Uniform +X

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 = 5.5509321E-005
Shear Force, Va = 1.0433598E-010
EDGE -B-
Bending Moment, Mb = -1.2679769E-005
Shear Force, Vb = -1.0433598E-010
BOTH EDGES
Axial Force, F = -2.3784E+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 = 489577.202

Vn ((10.3), ASCE 41-17) = knl*VCol0 = 489577.202
VCol = 489577.202
knl = 1.00
displacement_ductility_demand = 6.1324834E-011

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 = 1.2679769E-005
Vu = 1.0433598E-010
d = 0.8*D = 280.00
Nu = 2.3784E+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 = 5.8363442E-013
θy = (My*Ls/3)/EIeff = 0.00951709 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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

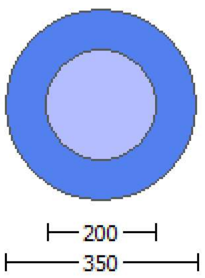
Limit State: Collapse Prevention (data interpolation between analysis steps 50 and 51)

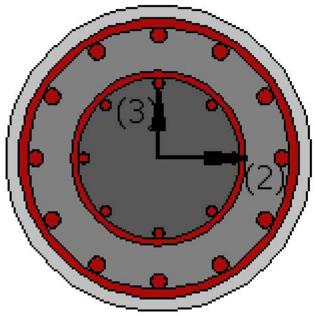
Analysis: Uniform +X

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 = 8.6468551E-029
EDGE -B-
Shear Force, Vb = -8.6468551E-029
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009

Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 5.0686070E-009
Vu = 8.6468551E-029
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -5.2944968E-045
EDGE -B-
Shear Force, Vb = 5.2944968E-045
BOTH EDGES
Axial Force, F = -2.3809E+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 = 0.40888624
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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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 = 958400.706
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 = 0.74912084
N = 2.3809E+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) = 534007.60

Calculation of Shear Strength at edge 1, Vr1 = 534007.60
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = 534007.60
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 534007.60
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 = 4.2335601E-009
Vu = 5.2944968E-045
d = 0.8*D = 280.00
Nu = 2.3809E+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 = -7.8578E+006
Shear Force, V2 = 38921.202
Shear Force, V3 = -1.0433598E-010
Axial Force, F = -2.3784E+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 = 0.00604105
θu = θy + θp = 0.00604105

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00190342 ((4.29),Biskinis Phd))
My = 2.6499E+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 = 2.3784E+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) = 2.6499E+008
Φy ((10a) or (10b)) = 1.4456279E-005
My_ten (8a) = 3.1367E+008
Φ_ten (7a) = 89.00
error of function (7a) = -0.60657796
My_com (8b) = 2.6499E+008
Φ_com (7b) = 100.7102
error of function (7b) = -0.00914571
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 = 0.74912084
N = 2.3784E+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 = 0.00413763
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.40888624
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 = 2.3784E+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)
