Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

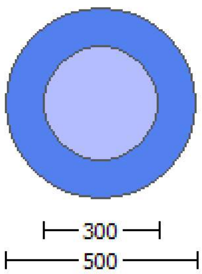
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

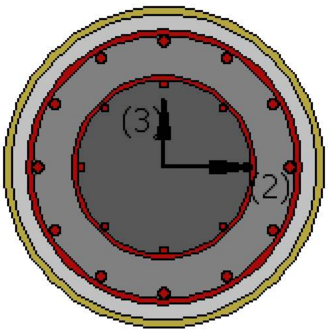
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4341E+007
Shear Force, Va = -4779.203
EDGE -B-
Bending Moment, Mb = 0.07981876
Shear Force, Vb = 4779.203
BOTH EDGES
Axial Force, F = -7387.302
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 = 515957.182
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 515957.182
VCol = 515957.182
knl = 1.00

displacement_ductility_demand = 0.01760997

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 = 1.4341E+007
Vu = 4779.203
d = 0.8*D = 400.00
Nu = 7387.302
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

---

displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation θ = 0.00015961
θy = (My*Ls/3)/Eleff = 0.00906346 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.736
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

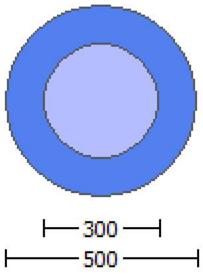
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

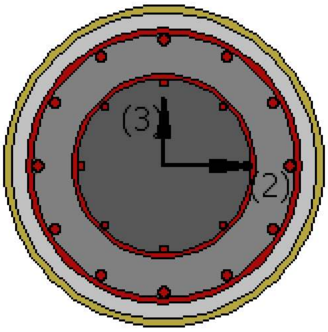
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, V_a = 3.4807814E-030
EDGE -B-
Shear Force, V_b = -3.4807814E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874

conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663

bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584

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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon

Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 7.3474831E-010
Shear Force, V2 = -4779.203
Shear Force, V3 = -2.1566928E-013
Axial Force, F = -7387.302
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 = 0.00453062
θu = θy + θp = 0.00453062

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00453062 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541

((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.23017425
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7387.302
Ag = 196349.541
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) = 0.015552
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

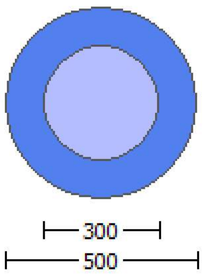
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

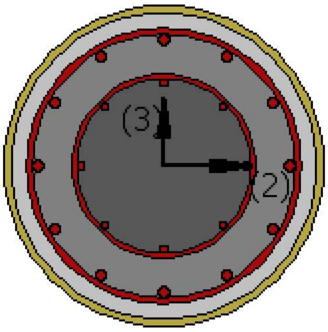
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 7.3474831E-010
Shear Force, Va = -2.1566928E-013
EDGE -B-
Bending Moment, Mb = -8.7529383E-011
Shear Force, Vb = 2.1566928E-013
BOTH EDGES
Axial Force, F = -7387.302
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 = 614519.957
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 614519.957
VCol = 614519.957
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.3474831E-010
Vu = 2.1566928E-013
d = 0.8*D = 400.00
Nu = 7387.302
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00

Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 9.5640318E-021
θy = (My*Ls/3)/EIeff = 0.00453062 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004

εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

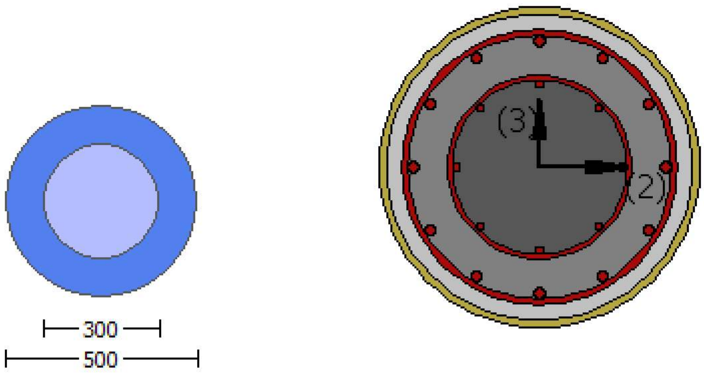
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)



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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.4807814E-030
EDGE -B-
Shear Force, Vb = -3.4807814E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008

Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813

N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.4341E+007
Shear Force, V2 = -4779.203
Shear Force, V3 = -2.1566928E-013
Axial Force, F = -7387.302
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 = 0.00906346 θu = θy + θp = 0.00906346

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00906346 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.736
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.23017425
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction

s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7387.302
Ag = 196349.541
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) = 0.015552
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

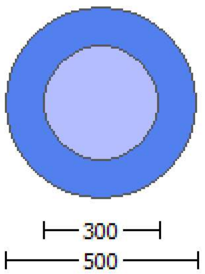
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

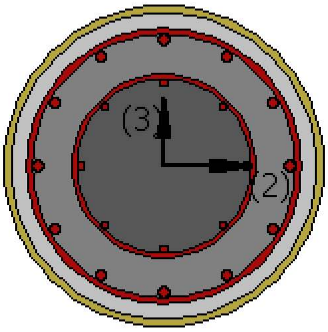
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4341E+007
Shear Force, Va = -4779.203
EDGE -B-
Bending Moment, Mb = 0.07981876
Shear Force, Vb = 4779.203
BOTH EDGES
Axial Force, F = -7387.302
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 = 614519.957
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 614519.957
VCol = 614519.957
knl = 1.00
displacement_ductility_demand = 0.09552499

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 = 0.07981876
Vu = 4779.203
d = 0.8*D = 400.00
Nu = 7387.302
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation θ = 8.6557465E-005
θy = (My*Ls/3)/Eleff = 0.00090612 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00

From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

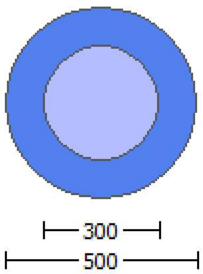
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

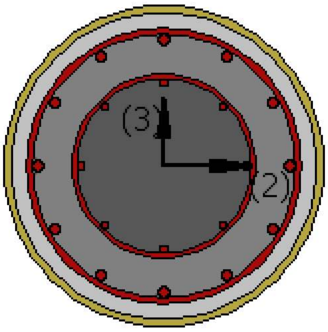
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.4807814E-030
EDGE -B-
Shear Force, Vb = -3.4807814E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813

N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -8.7529383E-011
Shear Force, V2 = 4779.203
Shear Force, V3 = 2.1566928E-013
Axial Force, F = -7387.302
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 = 0.00453062
θu = θy + θp = 0.00453062

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00453062 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008

Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.23017425
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7387.302
Ag = 196349.541
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) = 0.015552
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

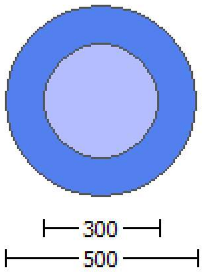
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

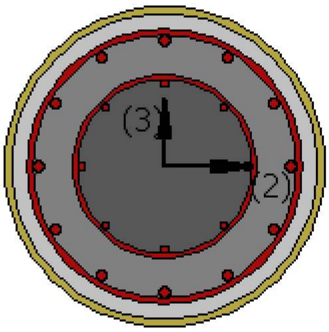
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 7.3474831E-010
Shear Force, Va = -2.1566928E-013
EDGE -B-
Bending Moment, Mb = -8.7529383E-011
Shear Force, Vb = 2.1566928E-013
BOTH EDGES
Axial Force, F = -7387.302
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 = 614519.957
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 614519.957
VCol = 614519.957
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.7529383E-011
Vu = 2.1566928E-013
d = 0.8*D = 400.00
Nu = 7387.302

Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 5.1499725E-021
θy = (My*Ls/3)/EIeff = 0.00453062 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)

d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

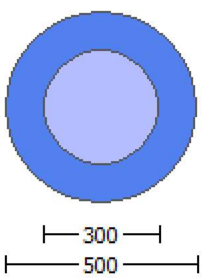
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

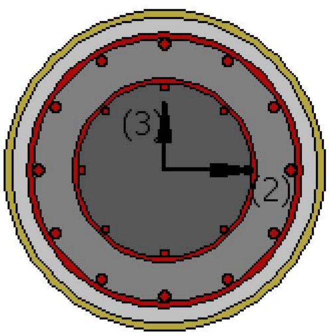
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00

Internal Diameter, D = 300.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.51481

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data

Type: Carbon

Dry properties (design values)

Thickness, t = 1.00

Tensile Strength, ffu = 840.00

Tensile Modulus, Ef = 82000.00

Elongation, efu = 0.009

Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°

Number of layers, NL = 1

Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, Va = 3.4807814E-030

EDGE -B-

Shear Force, Vb = -3.4807814E-030

BOTH EDGES

Axial Force, F = -7389.214

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 3053.628

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1017.876

-Compression: Asl,com = 1017.876

-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541

ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00

Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30

d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:

total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 0.07981876
Shear Force, V2 = 4779.203
Shear Force, V3 = 2.1566928E-013
Axial Force, F = -7387.302
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 = 0.00090612
θu = θy + θp = 0.00090612

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00090612 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7387.302
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424840E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.8137
error of function (7c) = 0.00026387
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67468
error of function (7d) = -0.0087488
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101374
N = 7387.302
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.23017425
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7387.302
Ag = 196349.541
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) = 0.015552
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

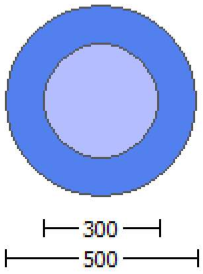
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

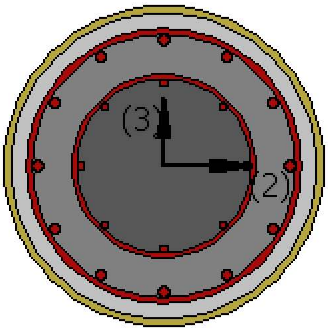
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1

Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.2653E+007
Shear Force, Va = -7549.016
EDGE -B-
Bending Moment, Mb = 0.12607815
Shear Force, Vb = 7549.016
BOTH EDGES
Axial Force, F = -7386.194
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 = 515957.072
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 515957.072
VCol = 515957.072
knl = 1.00
displacement_ductility_demand = 0.02781594

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 = 2.2653E+007
Vu = 7549.016
d = 0.8*D = 400.00
Nu = 7386.194
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00

ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation θ = 0.00025211
θy = (My*Ls/3)/EIeff = 0.00906345 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.736
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7386.194
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.81367
error of function (7c) = 0.00026388
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67467
error of function (7d) = -0.00874883
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101359
N = 7386.194
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

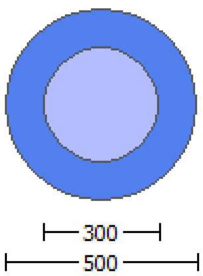
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

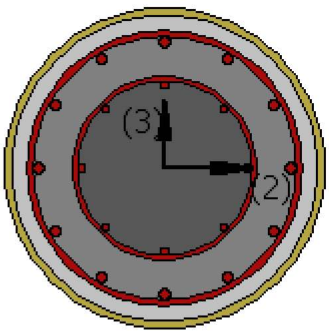
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.4807814E-030
EDGE -B-
Shear Force, Vb = -3.4807814E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00

R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00

dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874

conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663

bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 1.1533666E-009
Shear Force, V2 = -7549.016
Shear Force, V3 = -3.4066156E-013
Axial Force, F = -7386.194
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 = 0.03453062
θu = θy + θp = 0.03453062

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00453062 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7386.194

Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.81367
error of function (7c) = 0.00026388
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67467
error of function (7d) = -0.00874883
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101359
N = 7386.194
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.03
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.23017425
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7386.194
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00

fyIE = (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) = 0.015552
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

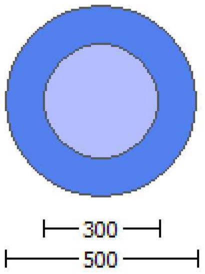
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

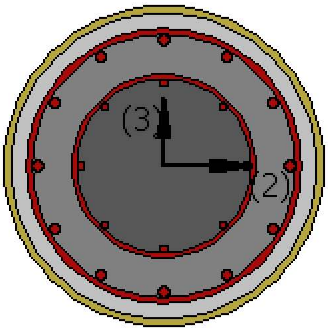
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.1533666E-009
Shear Force, Va = -3.4066156E-013
EDGE -B-
Bending Moment, Mb = -1.3104847E-010
Shear Force, Vb = 3.4066156E-013
BOTH EDGES
Axial Force, F = -7386.194
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 = 614519.737
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 614519.737
VCol = 614519.737
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1533666E-009
Vu = 3.4066156E-013
d = 0.8*D = 400.00
Nu = 7386.194
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.5106917E-020
θy = (My*Ls/3)/Eleff = 0.00453062 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7386.194
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.81367
error of function (7c) = 0.00026388
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67467
error of function (7d) = -0.00874883
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101359
N = 7386.194
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

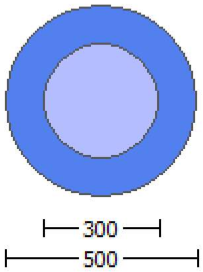
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

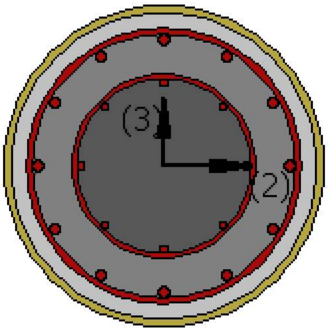
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.4807814E-030
EDGE -B-
Shear Force, Vb = -3.4807814E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874

conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663

bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.

Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584

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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon

Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -2.2653E+007
Shear Force, V2 = -7549.016
Shear Force, V3 = -3.4066156E-013
Axial Force, F = -7386.194
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 = 0.03906345
θu = θy + θp = 0.03906345

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00906345 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.736
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7386.194
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.81367
error of function (7c) = 0.00026388
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67467
error of function (7d) = -0.00874883
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101359
N = 7386.194
Ac = 196349.541

((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.03
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.23017425
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7386.194
Ag = 196349.541
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) = 0.015552
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

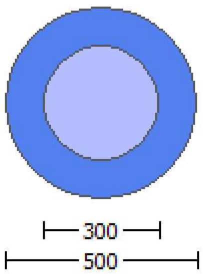
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

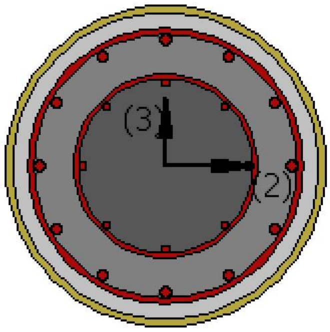
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.2653E+007
Shear Force, Va = -7549.016
EDGE -B-
Bending Moment, Mb = 0.12607815
Shear Force, Vb = 7549.016
BOTH EDGES
Axial Force, F = -7386.194
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 = 614519.737
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 614519.737
VCol = 614519.737
knl = 1.00
displacement_ductility_demand = 0.15088713

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 = 0.12607815
Vu = 7549.016
d = 0.8*D = 400.00
Nu = 7386.194
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00

Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation θ = 0.00013672
θy = (My*Ls/3)/EIeff = 0.00090612 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7386.194
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.81367
error of function (7c) = 0.00026388
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67467
error of function (7d) = -0.00874883
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101359
N = 7386.194
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004

εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

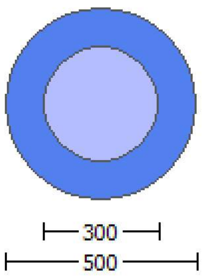
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

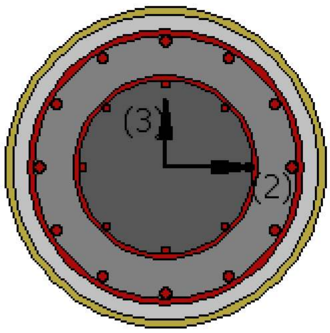
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.4807814E-030
EDGE -B-
Shear Force, Vb = -3.4807814E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008

Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813

N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
  conf. factor λc = 1.51481
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00100813
      N = 7389.214
      Ac = 196349.541
    ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 705811.584
  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 = 1.5940012E-011
    Vu = 2.1312935E-046
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 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 = 0.25
   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 = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 308320.00
   ψf = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.3104847E-010
Shear Force, V2 = 7549.016
Shear Force, V3 = 3.4066156E-013
Axial Force, F = -7386.194
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 = 0.03453062 θu = θy + θp = 0.03453062

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00453062 ((4.29),Biskinis Phd))
  My = 2.2517E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
   factor = 0.30
    Ag = 196349.541
    Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
    N = 7386.194
   Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
 My_ten (8c) = 2.2517E+008
 Φ_ten (7c) = 61.81367
 error of function (7c) = 0.00026388
 My_com (8d) = 8.1922E+008
 Φ_com (7d) = 63.67467
 error of function (7d) = -0.00874883
  with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
   eco = 0.002
   apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
   d1 = 44.00
   R = 250.00
   v = 0.00101359
   N = 7386.194
   Ac = 196349.541
  ((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
 with fc* ((12.3), ACI 440) = 37.11312
   fc = 33.00
   fl = 1.312
   kα = 1
    Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
   efe ((12.5) and (12.7)) = 0.004
   εfu = 0.009
   Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - Calculation of θp -

From table 10-9: θp = 0.03
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VCol0E = 0.23017425
  d = d_external = 0.00
  s = s_external = 0.00
  ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
  jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
    Av1 = 78.53982, is the area of stirrup
    Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction

s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7386.194
Ag = 196349.541
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) = 0.015552
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

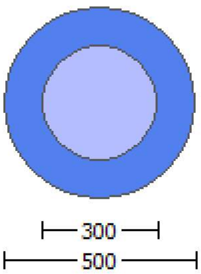
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

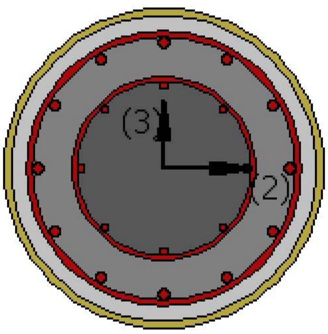
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Section Type: rcjcs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.1533666E-009
Shear Force, Va = -3.4066156E-013
EDGE -B-
Bending Moment, Mb = -1.3104847E-010
Shear Force, Vb = 3.4066156E-013
BOTH EDGES
Axial Force, F = -7386.194
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 = 614519.737
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 614519.737
VCol = 614519.737
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.3104847E-010
Vu = 3.4066156E-013
d = 0.8*D = 400.00
Nu = 7386.194
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
Vs1 = 246740.11 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 417394.406
bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 8.1346664E-021
θy = (My*Ls/3)/Eleff = 0.00453062 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00

From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7386.194
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
My_ten (8c) = 2.2517E+008
Φ_ten (7c) = 61.81367
error of function (7c) = 0.00026388
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67467
error of function (7d) = -0.00874883
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101359
N = 7386.194
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

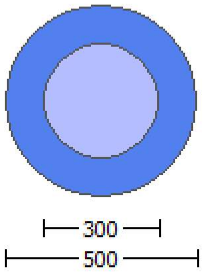
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

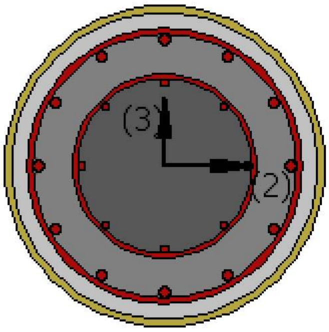
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.4807814E-030
EDGE -B-
Shear Force, Vb = -3.4807814E-030
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813

N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.2438899E-011
Vu = 3.4807814E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.51481
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.1312935E-046
EDGE -B-
Shear Force, Vb = 2.1312935E-046
BOTH EDGES
Axial Force, F = -7389.214
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.23017425
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162459.651
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4369E+008
Mu1+ = 2.4369E+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- = 2.4369E+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-) = 2.4369E+008
Mu2+ = 2.4369E+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- = 2.4369E+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 = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4369E+008

φ = 0.80285146
φ' = 0.71403327
error of function (3.68), Biskinis Phd = 27987.158
From 5A.2, TBDY: fcc = fc*λc = 49.98874
conf. factor λc = 1.51481
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 250.00
v = 0.00100813
N = 7389.214
Ac = 196349.541
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.1620683

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 705811.584

Calculation of Shear Strength at edge 1, Vr1 = 705811.584
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 705811.584
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 705811.584
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 = 1.5940012E-011
Vu = 2.1312935E-046
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 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 = 0.25
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 = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 308320.00
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 479549.663
bw*d = π*d*d/4 = 125663.706

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

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

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 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 = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 0.12607815
Shear Force, V2 = 7549.016
Shear Force, V3 = 3.4066156E-013
Axial Force, F = -7386.194
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 = 0.03090612
θu = θy + θp = 0.03090612

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00090612 ((4.29),Biskinis Phd))
My = 2.2517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
factor = 0.30
Ag = 196349.541
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 7386.194
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 2.2517E+008
Φy = 6.4424821E-006
My_ten (8c) = 2.2517E+008

Φ_ten (7c) = 61.81367
error of function (7c) = 0.00026388
My_com (8d) = 8.1922E+008
Φ_com (7d) = 63.67467
error of function (7d) = -0.00874883
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00101359
N = 7386.194
Ac = 196349.541
((10.1), ASCE 41-17) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.23280363
with fc* ((12.3), ACI 440) = 37.11312
fc = 33.00
fl = 1.312
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
efe ((12.5) and (12.7)) = 0.004
εfu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: θp = 0.03
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.23017425
d = d_external = 0.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00795744
jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
Av1 = 78.53982, is the area of stirrup
Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*(π*Dc2/2)/(s2*Ag) = 0.00046968
Av2 = 50.26548, is the area of stirrup
Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 7386.194
Ag = 196349.541
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) = 0.015552
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)