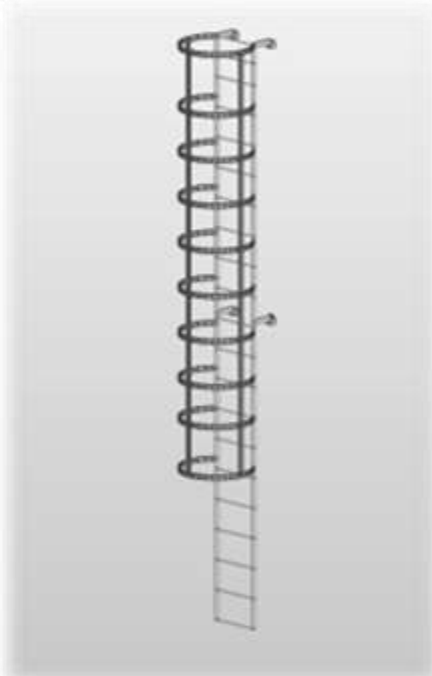


CAT LADDER DESIGN REPORT

2nd September 2023

Prepared by:
Sheilla Constance Apio

ANALYSIS MODEL

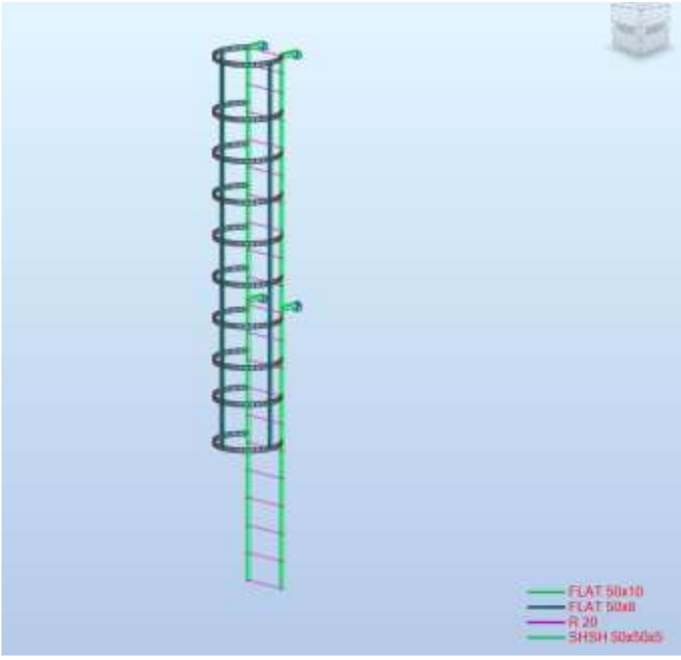


Figure 1 Analysis model

LOADING

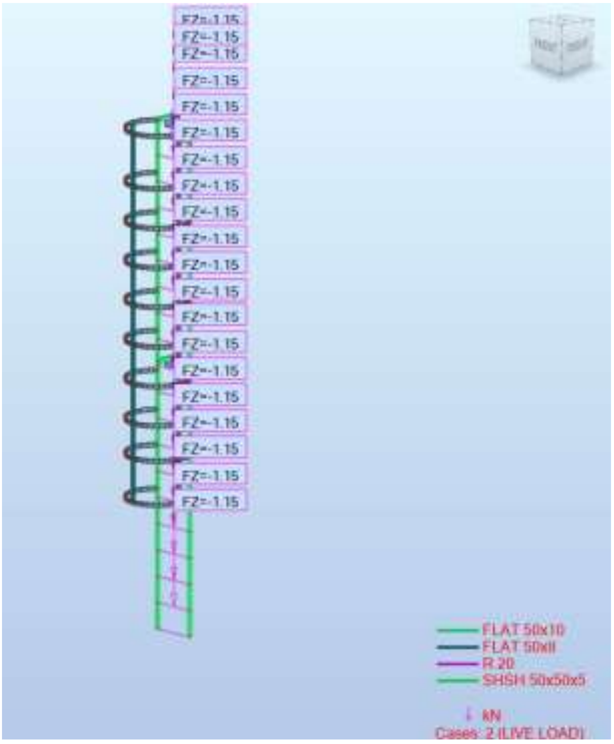


Figure 2 LIVE LOADING ON RUNGS

MODAL DISPLACEMENT

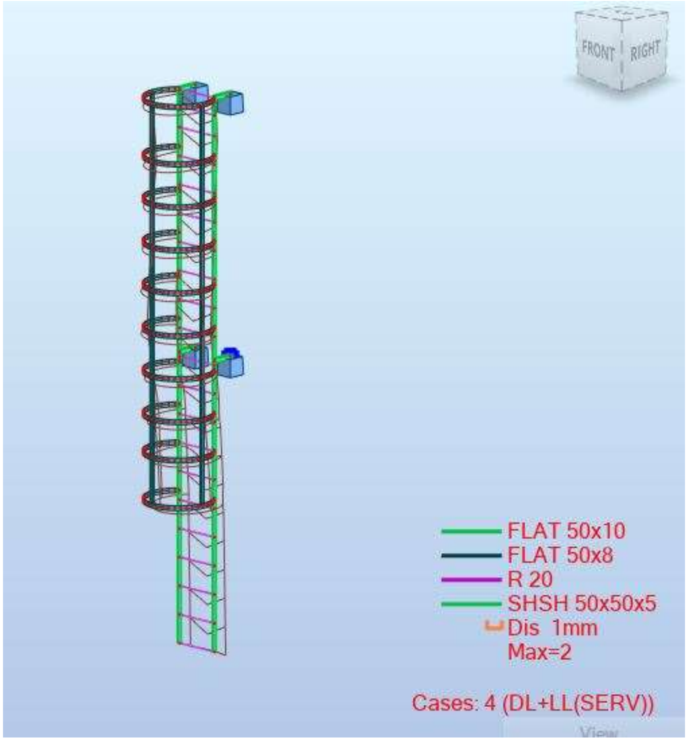


Figure 2 Modal displacement

LOAD CASES AND COMBINATIONS

No.	Combination
1	1.35D + 1.5(1.0LL)
2	SERV :1.0D + (1.0LL)

D – DEAD LOAD

LL -LIVELOAD

SERV – Serviceability

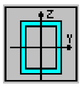
STEEL DESIGN

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Code Group Design

CODE GROUP: 1 Vertical stringers
MEMBER: 59 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

LOADS:
Governing Load Case: 3 DL+LL 1*1.35+2*1.50

MATERIAL:
S275 (S275) fy = 275.00 MPa



SECTION PARAMETERS: FLAT 50x10

h=50 mm	gM0=1.00	gM1=1.00	
b=10 mm	Ay=500 mm2	Az=500 mm2	Ax=500 mm2
tw=25 mm	Iy=104167 mm4	Iz=4167 mm4	Ix=14566 mm4
tf=25 mm	Wply=6250 mm3	Wplz=1250 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -8.27 kN	My,Ed = 0.18 kN*m	Mz,Ed = -0.07 kN*m	Vy,Ed = -0.99 kN
Nt,Rd = 137.50 kN	My,pl,Rd = 1.72 kN*m	Mz,pl,Rd = 0.34 kN*m	Vy,T,Rd = 79.34 kN
	My,c,Rd = 1.72 kN*m	Mz,c,Rd = 0.34 kN*m	Vz,Ed = 0.19 kN
	MN,y,Rd = 1.62 kN*m	MN,z,Rd = 0.11 kN*m	Vz,T,Rd = 79.34 kN
			Tt,Ed = -0.00 kN*m
			Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nt,Rd = 0.06 < 1.00 (6.2.3.(1))
(My,Ed/MN,y,Rd)^ 1.67 + (Mz,Ed/MN,z,Rd)^1.67 = 0.49 < 1.00 (6.2.9.1.(6))
Vy,Ed/Vy,T,Rd = 0.01 < 1.00 (6.2.6-7)
Vz,Ed/Vz,T,Rd = 0.00 < 1.00 (6.2.6-7)

Section OK !!!

STEEL DESIGN

-

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Code Group Design

-

CODE GROUP: 2 Straps
MEMBER: 254 **POINT:** 3 **COORDINATE:** x = 1.00 L = 0.45 m

-

LOADS:
Governing Load Case: 3 DL+LL 1*1.35+2*1.50

-

MATERIAL:
S275 (S275) fy = 275.00 MPa

-

SECTION PARAMETERS: FLAT 50x8

h=50 mm	gM0=1.00	gM1=1.00	
b=8 mm	Ay=400 mm2	Az=400 mm2	Ax=400 mm2
tw=25 mm	Iy=83333 mm4	Iz=2133 mm4	Ix=7673 mm4
tf=25 mm	Wply=5000 mm3	Wplz=800 mm3	

-

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.23 kN	My,Ed = -0.04 kN*m	Mz,Ed = -0.00 kN*m	Vy,Ed = 0.02 kN
Nc,Rd = 110.00 kN	My,Ed,max = 0.06 kN*m	Mz,Ed,max = 0.00 kN*m	Vy,T,Rd = 63.50 kN
Nb,Rd = 17.28 kN	My,c,Rd = 1.38 kN*m	Mz,c,Rd = 0.22 kN*m	Vz,Ed = -0.24 kN
	MN,y,Rd = 1.37 kN*m	MN,z,Rd = 0.06 kN*m	Vz,T,Rd = 63.50 kN
			Tt,Ed = 0.00 kN*m
			Class of section = 1

-

LATERAL BUCKLING PARAMETERS:

-

BUCKLING PARAMETERS:

About y axis:		About z axis:	
Ly = 0.45 m	Lam_y = 0.36	Lz = 0.45 m	Lam_z = 2.27
Lcr,y = 0.45 m	Xy = 0.92	Lcr,z = 0.45 m	Xz = 0.16
Lamy = 31.18	kzy = 0.60	Lamz = 194.86	kzz = 1.01

-

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nc,Rd = 0.00 < 1.00 (6.2.4.(1))
(My,Ed/MN,y,Rd)^ 1.66 + (Mz,Ed/MN,z,Rd)^1.66 = 0.02 < 1.00 (6.2.9.1.(6))
Vy,Ed/Vy,T,Rd = 0.00 < 1.00 (6.2.6-7)
Vz,Ed/Vz,T,Rd = 0.00 < 1.00 (6.2.6-7)
Global stability check of member:
Lambda,y = 31.18 < Lambda,max = 260.00 Lambda,z = 194.86 < Lambda,max = 260.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.06 < 1.00 (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) + kzz*Mz,Ed,max/(Mz,Rk/gM1) = 0.06 < 1.00   (6.3.3.(4))

Section OK !!!

STEEL DESIGN

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Code Group Design

CODE GROUP: 3 Hoop
MEMBER: 125   **POINT:** 1   **COORDINATE:** x = 0.00 L = 0.00 m

LOADS:
Governing Load Case: 3 DL+LL 1*1.35+2*1.50

MATERIAL:
S275 (S275)   fy = 275.00 MPa

SECTION PARAMETERS: FLAT 50x8

h=50 mm	gM0=1.00	gM1=1.00	
b=8 mm	Ay=400 mm2	Az=400 mm2	Ax=400 mm2
tw=25 mm	Iy=83333 mm4	Iz=2133 mm4	Ix=7673 mm4
tf=25 mm	Wply=5000 mm3	Wplz=800 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.30 kN	My,Ed = 0.01 kN*m	Mz,Ed = 0.02 kN*m	Vy,Ed = 0.19 kN
Nc,Rd = 110.00 kN	My,Ed,max = 0.01 kN*m	Mz,Ed,max = 0.02 kN*m	Vy,T,Rd = 63.49 kN
Nb,Rd = 110.00 kN	My,c,Rd = 1.38 kN*m	Mz,c,Rd = 0.22 kN*m	Vz,Ed = -0.05 kN
	MN,y,Rd = 1.37 kN*m	MN,z,Rd = 0.06 kN*m	Vz,T,Rd = 63.49 kN
	Mb,Rd = 1.38 kN*m		Tt,Ed = 0.00 kN*m
			Class of section = 1

LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 600.40 kN*m	Curve,LT - d	XLT = 1.00
Lcr,upp=0.04 m	Lam_LT = 0.05	fi,LT = 0.37	XLT,mod = 1.00

BUCKLING PARAMETERS:

About y axis:		About z axis:	
	kyy = 1.00		kzz = 1.00

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nc,Rd = 0.00 < 1.00   (6.2.4.(1))
(My,Ed/MN,y,Rd)^ 1.66 + (Mz,Ed/MN,z,Rd)^1.66 = 0.10 < 1.00   (6.2.9.1.(6))

Vy,Ed/Vy,T,Rd = 0.00 < 1.00   (6.2.6-7)
Vz,Ed/Vz,T,Rd = 0.00 < 1.00   (6.2.6-7)

Global stability check of member:

My,Ed,max/Mb,Rd = 0.00 < 1.00   (6.3.2.1.(1))
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.08 < 1.00   (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) + kzz*Mz,Ed,max/(Mz,Rk/gM1) = 0.08 < 1.00   (6.3.3.(4))

-

Section OK !!!

STEEL DESIGN

-

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Code Group Design

-

CODE GROUP: 4 Rungs(steps)
MEMBER: 16   **POINT:** 1   **COORDINATE:** x = 0.50 L = 0.25 m

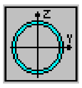
----
-

LOADS:
Governing Load Case: 3 DL+LL 1*1.35+2*1.50

-

MATERIAL:
S275 (S275)   fy = 275.00 MPa

-



SECTION PARAMETERS: R 20

h=20 mm	gM0=1.00	gM1=1.00	
	Ay=200 mm2	Az=200 mm2	Ax=314 mm2
tw=10 mm	Iy=7854 mm4	Iz=7854 mm4	Ix=15708 mm4
	Wply=1333 mm3	Wplz=1333 mm3	

-

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.04 kN	My,Ed = 0.13 kN*m	Mz,Ed = 0.00 kN*m	Vy,Ed = 0.00 kN
Nc,Rd = 86.39 kN	My,pl,Rd = 0.37 kN*m	Mz,pl,Rd = 0.37 kN*m	Vy,T,Rd = 31.75 kN
Nb,Rd = 86.39 kN	My,c,Rd = 0.37 kN*m	Mz,c,Rd = 0.37 kN*m	Vz,Ed = -0.86 kN
	MN,y,Rd = 0.37 kN*m	MN,z,Rd = 0.37 kN*m	Vz,T,Rd = 31.75 kN
			Tt,Ed = 0.00 kN*m
			Class of section = 1

-

LATERAL BUCKLING PARAMETERS:

-

BUCKLING PARAMETERS:

About y axis:

About z axis:

-

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nc,Rd = 0.00 < 1.00 (6.2.4.(1))
(My,Ed/MN,y,Rd)^ 2.00 + (Mz,Ed/MN,z,Rd)^2.00 = 0.13 < 1.00 (6.2.9.1.(6))
Vy,Ed/Vy,T,Rd = 0.00 < 1.00 (6.2.6-7)
Vz,Ed/Vz,T,Rd = 0.03 < 1.00 (6.2.6-7)
Tau,ty,Ed/(fy/(sqrt(3)*gM0)) = 0.00 < 1.00 (6.2.6)
Tau,tz,Ed/(fy/(sqrt(3)*gM0)) = 0.00 < 1.00 (6.2.6)

-

Section OK !!!

STEEL DESIGN

-

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Code Group Design

-

CODE GROUP: 5 Anchor Supports
MEMBER: 229 **POINT:** 3 **COORDINATE:** x = 1.00 L = 0.23 m

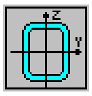
-

LOADS:
Governing Load Case: 3 DL+LL 1*1.35+2*1.50

-

MATERIAL:
S275 (S275) fy = 275.00 MPa

-



SECTION PARAMETERS: SHSH 50x50x5

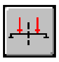
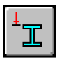
h=50 mm	gM0=1.00	gM1=1.00	
b=50 mm	Ay=437 mm2	Az=437 mm2	Ax=873 mm2
tw=5 mm	Iy=289000 mm4	Iz=289000 mm4	Ix=476000 mm4
tf=5 mm	Wply=14500 mm3	Wplz=14500 mm3	

-

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.35 kN	My,Ed = -1.90 kN*m	Mz,Ed = -0.16 kN*m	Vy,Ed = 0.73 kN
Nc,Rd = 240.07 kN	My,Ed,max = -1.90 kN*m		Mz,Ed,max = -0.16 kN*m
	Vy,T,Rd = 69.19 kN		
Nb,Rd = 240.07 kN	My,c,Rd = 3.99 kN*m	Mz,c,Rd = 3.99 kN*m	Vz,Ed = -10.22 kN
	MN,y,Rd = 3.99 kN*m	MN,z,Rd = 3.99 kN*m	Vz,T,Rd = 69.19 kN
	Mb,Rd = 3.99 kN*m		Tt,Ed = 0.01 kN*m
			Class of section = 1

-

LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 588.43 kN*m	Curve,LT - d	XLT = 1.00
Lcr,low=0.23 m	Lam_LT = 0.08	fi,LT = 0.38	XLT,mod = 1.00

-

BUCKLING PARAMETERS:

About y axis: About z axis:

kyy = 1.00 kzz = 1.00

-

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.00 < 1.00 (6.2.4.(1))
(My,Ed/MN,y,Rd)^ 1.66 + (Mz,Ed/MN,z,Rd)^1.66 = 0.30 < 1.00 (6.2.9.1.(6))
Vy,Ed/Vy,T,Rd = 0.01 < 1.00 (6.2.6-7)
Vz,Ed/Vz,T,Rd = 0.15 < 1.00 (6.2.6-7)
Tau,ty,Ed/(fy/(sqrt(3)*gM0)) = 0.00 < 1.00 (6.2.6)
Tau,tz,Ed/(fy/(sqrt(3)*gM0)) = 0.00 < 1.00 (6.2.6)

Global stability check of member:

My,Ed,max/Mb,Rd = 0.48 < 1.00 (6.3.2.1.(1))
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.52 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) + kzz*Mz,Ed,max/(Mz,Rk/gM1) = 0.52 < 1.00 (6.3.3.(4))

-

Section OK !!!

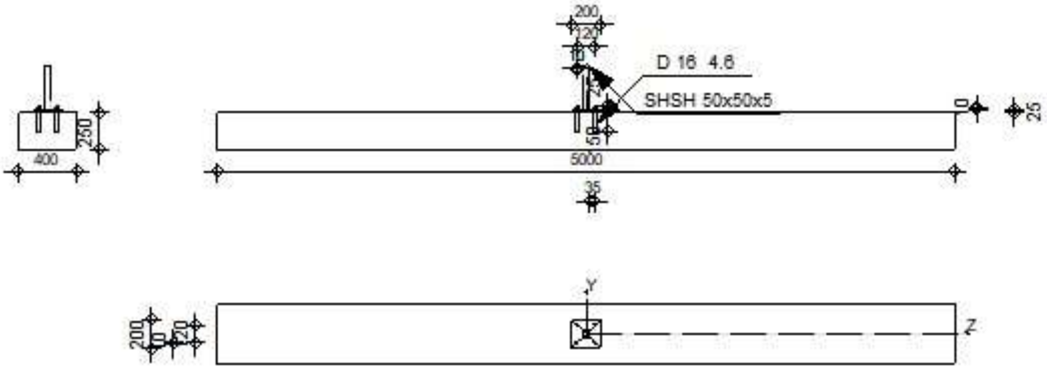
Autodesk Robot Structural Analysis Professional 2019

Fixed column base design

Eurocode 3: EN 1993-1-8:2005/AC:2009 + CEB Design Guide: Design of fastenings in concrete

OK

Ratio
0.56



GENERAL

Connection no.: 1

Connection name: Fixed column base

Structure node: 205

Structure bars: 229

GEOMETRY

COLUMN

Section: SHSH 50x50x5

Bar no.: 229

L_c =	0.23	[m]	Column length
α =	180.0	[Deg]	Inclination angle
h_c =	50	[mm]	Height of column section
b_{fc} =	50	[mm]	Width of column section
t_{wc} =	5	[mm]	Thickness of the web of column section
t_{fc} =	5	[mm]	Thickness of the flange of column section
r_c =	5	[mm]	Radius of column section fillet
A_c =	873	[mm^2]	Cross-sectional area of a column
I_{yc} =	289000	[mm^4]	Moment of inertia of the column section

Material: S275

f_{yc} = 275.00 [MPa] Resistance

f_{uc} = 430.00 [MPa] Yield strength of a material

COLUMN BASE

l_{pd} = 200 [mm] Length

b_{pd} = 200 [mm] Width

t_{pd} = 25 [mm] Thickness

Material: S275

f_{ypd} = 275.00 [MPa] Resistance

f_{upd} = 430.00 [MPa] Yield strength of a material

ANCHORAGE

The shear plane passes through the UNTHREADED portion of the bolt.

Class = 4.6 Anchor class

f_{yb} = 240.00 [MPa] Yield strength of the anchor material

f_{ub} = 400.00 [MPa] Tensile strength of the anchor material

d = 16 [mm] Bolt diameter

A_s = 157 [mm^2] Effective section area of a bolt

A_v = 201 [mm^2] Area of bolt section

n_H = 2 Number of bolt columns

n_V = 2 Number of bolt rows

Horizontal spacing e_{Hi} = 120 [mm]

Vertical spacing e_{Vi} = 120 [mm]

Anchor dimensions

L_1 = 25 [mm]

L_2 = 150 [mm]

Washer

l_{wd} = 10 [mm] Length

b_{wd} = 10 [mm] Width

t_{wd} = 10 [mm] Thickness

MATERIAL FACTORS

γ_{M0} = 1.00 Partial safety factor

γ_{M2} = 1.25 Partial safety factor

γ_{M0} = 1.00 Partial safety factor

γ_C = 1.50 Partial safety factor

SPREAD FOOTING

L = 5000 [mm] Spread footing length

B = 400 [mm] Spread footing width

H = 250 [mm] Spread footing height

Concrete

Class C20

f_{ck} = 20.00 [MPa] Characteristic resistance for compression

Grout layer

t_g = 0 [mm] Thickness of leveling layer (grout)

$f_{ck,g}$ = 12.00 [MPa] Characteristic resistance for compression

$C_{f,d}$ = 0.30 Coeff. of friction between the base plate and concrete

WELDS

a_p = 6 [mm] Footing plate of the column base

LOADS

Case: 3: DL+LL 1*1.35+2*1.50

$N_{j,Ed}$ = -0.35 [kN] Axial force

$V_{j,Ed,y}$ = 0.73 [kN] Shear force

$V_{j,Ed,z}$ = 10.22 [kN] Shear force

$M_{j,Ed,y}$ = -1.90 [kN*m] Bending moment

$M_{j,Ed,z}$ = 0.16 [kN*m] Bending moment

RESULTS

COMPRESSION ZONE

COMPRESSION OF CONCRETE

f_{cd} = 13.33 [MPa] Design compressive resistance EN 1992-1:[3.1.6.(1)]

f_j = 18.86 [MPa] Design bearing resistance under the base plate [6.2.5.(7)]

$c = t_p \sqrt{(f_{yp}/(3*f_j*\gamma_{M0}))}$

c = 55 [mm] Additional width of the bearing pressure zone [6.2.5.(4)]

b_{eff} = 115 [mm] Effective width of the bearing pressure zone under the flange [6.2.5.(3)]

c =	55	[mm]	Additional width of the bearing pressure zone	[6.2.5.(4)]
l_{eff} =	160	[mm]	Effective length of the bearing pressure zone under the flange	[6.2.5.(3)]
A_{c0} =	18467	[mm^2]	Area of the joint between the base plate and the foundation	EN 1992-1:[6.7.(3)]
A_{c1} =	138291	[mm^2]	Maximum design area of load distribution	EN 1992-1:[6.7.(3)]

$F_{rdu} = A_{c0}*f_{cd}*\sqrt{(A_{c1}/A_{c0})} \leq 3*A_{c0}*f_{cd}$

F_{rdu} =	673.80	[kN]	Bearing resistance of concrete	EN 1992-1:[6.7.(3)]
β_j =	0.67		Reduction factor for compression	[6.2.5.(7)]

$f_{jd} = \beta_j*F_{rdu}/(b_{eff}*l_{eff})$

f_{jd} =	24.32	[MPa]	Design bearing resistance	[6.2.5.(7)]
$A_{c,n}$ =	22885	[mm^2]	Bearing area for compression	[6.2.8.2.(1)]
$A_{c,y}$ =	11442	[mm^2]	Bearing area for bending My	[6.2.8.3.(1)]
$A_{c,z}$ =	11442	[mm^2]	Bearing area for bending Mz	[6.2.8.3.(1)]

$F_{c,Rd,i} = A_{C,i}*f_{jd}$

$F_{c,Rd,n}$ =	556.67	[kN]	Bearing resistance of concrete for compression	[6.2.8.2.(1)]
$F_{c,Rd,y}$ =	278.34	[kN]	Bearing resistance of concrete for bending My	[6.2.8.3.(1)]
$F_{c,Rd,z}$ =	278.34	[kN]	Bearing resistance of concrete for bending Mz	[6.2.8.3.(1)]

COLUMN FLANGE AND WEB IN COMPRESSION

CL =	1.00		Section class	EN 1993-1-1:[5.5.2]
$W_{pl,y}$ =	14500	[mm^3]	Plastic section modulus	EN1993-1-1:[6.2.5.(2)]
$M_{c,Rd,y}$ =	3.99	[kN*m]	Design resistance of the section for bending	EN1993-1-1:[6.2.5]
$h_{f,y}$ =	45	[mm]	Distance between the centroids of flanges	[6.2.6.7.(1)]

$F_{c,fc,Rd,y} = M_{c,Rd,y} / h_{f,y}$

$F_{c,fc,Rd,y}$ =	88.61	[kN]	Resistance of the compressed flange and web	[6.2.6.7.(1)]
$W_{pl,z}$ =	14500	[mm^3]	Plastic section modulus	EN1993-1-1:[6.2.5.(2)]
$M_{c,Rd,z}$ =	3.99	[kN*m]	Design resistance of the section for bending	EN1993-1-1:[6.2.5]
$h_{f,z}$ =	45	[mm]	Distance between the centroids of flanges	[6.2.6.7.(1)]

$F_{c,fc,Rd,z} = M_{c,Rd,z} / h_{f,z}$

$F_{c,fc,Rd,z}$ =	88.61	[kN]	Resistance of the compressed flange and web	[6.2.6.7.(1)]

RESISTANCES OF SPREAD FOOTING IN THE COMPRESSION ZONE

$N_{j,Rd} = F_{c,Rd,n}$

$N_{j,Rd}$ =	556.67	[kN]	Resistance of a spread footing for axial compression	[6.2.8.2.(1)]

$F_{C,Rd,y} = \min(F_{c,Rd,y},F_{c,fc,Rd,y})$

$F_{C,Rd,y}$ =	88.61	[kN]	Resistance of spread footing in the compression zone	[6.2.8.3]

$F_{C,Rd,z} = \min(F_{c,Rd,z}, F_{c,fc,Rd,z})$

$F_{C,Rd,z}$ =	88.61	[kN]	Resistance of spread footing in the compression zone	[6.2.8.3]

TENSION ZONE

STEEL FAILURE

A_b =	157	[mm^2]	Effective anchor area	[Table 3.4]
f_{ub} =	400.00	[MPa]	Tensile strength of the anchor material	[Table 3.4]
Beta =	0.85		Reduction factor of anchor resistance	[3.6.1.(3)]

$F_{t,Rd,s1} = beta*0.9*f_{ub}*A_b/\gamma_{M2}$

$F_{t,Rd,s1}$ =	38.43	[kN]	Anchor resistance to steel failure	[Table 3.4]
γ_{Ms} =	1.20		Partial safety factor	CEB [3.2.3.2]
f_{yb} =	240.00	[MPa]	Yield strength of the anchor material	CEB [9.2.2]

$F_{t,Rd,s2} = f_{yb}*A_b/\gamma_{Ms}$

$F_{t,Rd,s2}$ =	31.40	[kN]	Anchor resistance to steel failure	CEB [9.2.2]

$F_{t,Rd,s} = \min(F_{t,Rd,s1}, F_{t,Rd,s2})$

$F_{t,Rd,s}$ =	31.40	[kN]	Anchor resistance to steel failure	

PULL-OUT FAILURE

f_{ck} =	20.00	[MPa]	Characteristic compressive strength of concrete	EN 1992-1:[3.1.2]

$f_{ctd} = 0.7*0.3*f_{ck}^{2/3}/\gamma_C$

f_{ctd} =	1.03	[MPa]	Design tensile resistance	EN 1992-1:[8.4.2.(2)]
η_1 =	1.00		Coeff. related to the quality of the bond conditions and concreting conditions	EN 1992-1:[8.4.2.(2)]
η_2 =	1.00		Coeff. related to the bar diameter	EN 1992-1:[8.4.2.(2)]

$f_{bd} = 2.25*\eta_1*\eta_2*f_{ctd}$

f_{bd} =	2.32	[MPa]	Design value of the ultimate bond stress	EN 1992-1:[8.4.2.(2)]
h_{ef} =	150	[mm]	Effective anchorage depth	EN 1992-1:[8.4.2.(2)]

$F_{t,Rd,p} = \pi*d*h_{ef}*f_{bd}$

$F_{t,Rd,p}$ =	17.50	[kN]	Design uplift capacity	EN 1992-1:[8.4.2.(2)]

CONCRETE CONE FAILURE

h_{ef} =	150	[mm]	Effective anchorage depth	CEB [9.2.4]

$N_{Rk,c}^{0} = 7.5[N^{0.5}/mm^{0.5}]*f_{ck}*h_{ef}^{1.5}$

$N_{Rk,c}^{0}$ =	61.62	[kN]	Characteristic resistance of an anchor	CEB [9.2.4]
$s_{cr,N}$ =	450	[mm]	Critical width of the concrete cone	CEB [9.2.4]
$c_{cr,N}$ =	225	[mm]	Critical edge distance	CEB [9.2.4]
$A_{c,N0}$ =	324900	[mm^2]	Maximum area of concrete cone	CEB [9.2.4]
$A_{c,N}$ =	228000	[mm^2]	Actual area of concrete cone	CEB [9.2.4]

$\psi_{A,N} = A_{c,N}/A_{c,N0}$

$\psi_{A,N}$ =	0.70		Factor related to anchor spacing and edge distance	CEB [9.2.4]
c =	140	[mm]	Minimum edge distance from an anchor	CEB [9.2.4]

$\psi_{s,N} = 0.7 + 0.3*c/c_{cr.N} \leq 1.0$

$\psi_{s,N}$ =	0.89	Factor taking account the influence of edges of the concrete member on the distribution of stresses in the concrete	CEB [9.2.4]
$\psi_{ec,N}$ =	1.00	Factor related to distribution of tensile forces acting on anchors	CEB [9.2.4]

$\psi_{re,N} = 0.5 + h_{ef}[mm]/200 \leq 1.0$

$\psi_{re,N}$ =	1.00	Shell spalling factor	CEB [9.2.4]
$\psi_{ucr,N}$ =	1.00	Factor taking into account whether the anchorage is in cracked or non-cracked concrete	CEB [9.2.4]
γ_{Mc} =	2.16	Partial safety factor	CEB [3.2.3.1]

$F_{t,Rd,c} = N_{Rk,c}^{0}*\psi_{A,N}*\psi_{s,N}*\psi_{ec,N}*\psi_{re,N}*\psi_{ucr,N}/\gamma_{Mc}$

$F_{t,Rd,c}$ =	17.75	[kN]	Design anchor resistance to concrete cone failure	EN 1992-1:[8.4.2.(2)]

SPLITTING FAILURE

h_{ef} =	150	[mm]	Effective anchorage depth	CEB [9.2.5]

$N_{Rk,c}^{0} = 7.5[N^{0.5}/mm^{0.5}]*f_{ck}*h_{ef}^{1.5}$

$N_{Rk,c}^{0}$ =	61.62	[kN]	Design uplift capacity	CEB [9.2.5]
$s_{cr,N}$ =	300	[mm]	Critical width of the concrete cone	CEB [9.2.5]
$c_{cr,N}$ =	150	[mm]	Critical edge distance	CEB [9.2.5]
$A_{c,N0}$ =	176400	[mm^2]	Maximum area of concrete cone	CEB [9.2.5]
$A_{c,N}$ =	168000	[mm^2]	Actual area of concrete cone	CEB [9.2.5]

$\psi_{A,N} = A_{c,N}/A_{c,N0}$

$\psi_{A,N}$ =	0.95		Factor related to anchor spacing and edge distance	CEB [9.2.5]
c =	140	[mm]	Minimum edge distance from an anchor	CEB [9.2.5]

$\psi_{s,N} = 0.7 + 0.3*c/c_{cr.N} \leq 1.0$

$\psi_{s,N}$ =	0.98	Factor taking account the influence of edges of the concrete member on the distribution of stresses in the concrete	CEB [9.2.5]
$\psi_{ec,N}$ =	1.00	Factor related to distribution of tensile forces acting on anchors	CEB [9.2.5]

$\psi_{re,N} = 0.5 + h_{ef}[mm]/200 \leq 1.0$

$\psi_{re,N}$ =	1.00	Shell spalling factor	CEB [9.2.5]
$\psi_{ucr,N}$ =	1.00	Factor taking into account whether the anchorage is in cracked or non-cracked concrete	CEB [9.2.5]

$\psi_{h,N} = (h/(2*h_{ef}))^{2/3} \leq 1.2$

$\psi_{h,N}$ =	0.89		Coeff. related to the foundation height	CEB [9.2.5]
$\gamma_{M,sp}$ =	2.16		Partial safety factor	CEB [3.2.3.1]

$F_{t,Rd,sp} = N_{Rk,c}{}^{0}*\psi_{A,N}*\psi_{s,N}*\psi_{ec,N}*\psi_{re,N}*\psi_{ucr,N}*\psi_{h,N}/\gamma_{M,sp}$

$F_{t,Rd,sp}$ =	23.58	[kN]	Design anchor resistance to splitting of concrete	CEB [9.2.5]

TENSILE RESISTANCE OF AN ANCHOR

$F_{t,Rd} = \min(F_{t,Rd,s}, F_{t,Rd,p}, F_{t,Rd,c}, F_{t,Rd,sp})$

$F_{t,Rd}$ =	17.50	[kN]	Tensile resistance of an anchor

BENDING OF THE BASE PLATE

Bending moment $M_{j,Ed,y}$

$l_{eff,1}$ =	100	[mm]	Effective length for a single bolt for mode 1	[6.2.6.5]
$l_{eff,2}$ =	100	[mm]	Effective length for a single bolt for mode 2	[6.2.6.5]
m =	49	[mm]	Distance of a bolt from the stiffening edge	[6.2.6.5]
$M_{pl,1,Rd}$ =	4.30	[kN*m]	Plastic resistance of a plate for mode 1	[6.2.4]
$M_{pl,2,Rd}$ =	4.30	[kN*m]	Plastic resistance of a plate for mode 2	[6.2.4]
$F_{T,1,Rd}$ =	347.24	[kN]	Resistance of a plate for mode 1	[6.2.4]
$F_{T,2,Rd}$ =	99.69	[kN]	Resistance of a plate for mode 2	[6.2.4]
$F_{T,3,Rd}$ =	35.00	[kN]	Resistance of a plate for mode 3	[6.2.4]

$F_{t,pl,Rd,y} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$

$F_{t,pl,Rd,y}$ =	35.00	[kN]	Tension resistance of a plate	[6.2.4]

Bending moment $M_{j,Ed,z}$

$l_{eff,1}$ =	100	[mm]	Effective length for a single bolt for mode 1	[6.2.6.5]
$l_{eff,2}$ =	100	[mm]	Effective length for a single bolt for mode 2	[6.2.6.5]
m =	49	[mm]	Distance of a bolt from the stiffening edge	[6.2.6.5]
$M_{pl,1,Rd}$ =	4.30	[kN*m]	Plastic resistance of a plate for mode 1	[6.2.4]

Bending moment $M_{j,Ed,z}$

$l_{eff,1}$ =	100	[mm]	Effective length for a single bolt for mode 1	[6.2.6.5]
$M_{pl,2,Rd}$ =	4.30	[kN*m]	Plastic resistance of a plate for mode 2	[6.2.4]
$F_{T,1,Rd}$ =	347.24	[kN]	Resistance of a plate for mode 1	[6.2.4]
$F_{T,2,Rd}$ =	99.69	[kN]	Resistance of a plate for mode 2	[6.2.4]
$F_{T,3,Rd}$ =	35.00	[kN]	Resistance of a plate for mode 3	[6.2.4]

$F_{t,pl,Rd,z} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$

$F_{t,pl,Rd,z}$ =	35.00	[kN]	Tension resistance of a plate	[6.2.4]

RESISTANCES OF SPREAD FOOTING IN THE TENSION ZONE

$F_{T,Rd,y} = F_{t,pl,Rd,y}$

$F_{T,Rd,y}$ =	35.00	[kN]	Resistance of a column base in the tension zone	[6.2.8.3]

$F_{T,Rd,z} = F_{t,pl,Rd,z}$

$F_{T,Rd,z}$ =	35.00	[kN]	Resistance of a column base in the tension zone	[6.2.8.3]

CONNECTION CAPACITY CHECK

$N_{j,Ed} / N_{j,Rd} \leq 1,0$ (6.24)	0.00 < 1.00	verified	(0.00)

e_y =	5483	[mm]	Axial force eccentricity	[6.2.8.3]
$z_{c,y}$ =	47	[mm]	Lever arm $F_{C,Rd,y}$	[6.2.8.1.(2)]
$z_{t,y}$ =	60	[mm]	Lever arm $F_{T,Rd,y}$	[6.2.8.1.(3)]
$M_{j,Rd,y}$ =	3.78	[kN*m]	Connection resistance for bending	[6.2.8.3]

$M_{j,Ed,y} / M_{j,Rd,y} \leq 1,0$ (6.23)	0.50 < 1.00	verified	(0.50)

e_z =	463	[mm]	Axial force eccentricity	[6.2.8.3]
$z_{c,z}$ =	23	[mm]	Lever arm $F_{C,Rd,z}$	[6.2.8.1.(2)]
$z_{t,z}$ =	60	[mm]	Lever arm $F_{T,Rd,z}$	[6.2.8.1.(3)]
$M_{j,Rd,z}$ =	3.03	[kN*m]	Connection resistance for bending	[6.2.8.3]

$M_{j,Ed,z} / M_{j,Rd,z} \leq 1,0$ (6.23)	0.05 < 1.00	verified	(0.05)
$M_{j,Ed,y} / M_{j,Rd,y} + M_{j,Ed,z} / M_{j,Rd,z} \leq 1,0$	0.56 < 1.00	verified	(0.56)

SHEAR

BEARING PRESSURE OF AN ANCHOR BOLT ONTO THE BASE PLATE

Shear force $V_{j,Ed,y}$

$\alpha_{d,y}$ =	0.74	Coeff. taking account of the bolt position - in the direction of shear	[Table 3.4]
$\alpha_{b,y}$ =	0.74	Coeff. for resistance calculation $F_{1,vb,Rd}$	[Table 3.4]

Shear force $V_{j,Ed,y}$

$\alpha_{d,y}$ = 0.74 Coeff. taking account of the bolt position - in the direction of shear [Table 3.4]

$k_{1,y}$ = 2.50 Coeff. taking account of the bolt position - perpendicularly to the direction of shear [Table 3.4]

$F_{1,vb,Rd,y} = k_{1,y}*\alpha_{b,y}*f_{up}*d*t_p / \gamma_{M2}$

$F_{1,vb,Rd,y}$ = 254.81 [kN] Resistance of an anchor bolt for bearing pressure onto the base plate [6.2.2.(7)]

Shear force $V_{j,Ed,z}$

$\alpha_{d,z}$ = 0.74 Coeff. taking account of the bolt position - in the direction of shear [Table 3.4]

$\alpha_{b,z}$ = 0.74 Coeff. for resistance calculation $F_{1,vb,Rd}$ [Table 3.4]

$k_{1,z}$ = 2.50 Coeff. taking account of the bolt position - perpendicularly to the direction of shear [Table 3.4]

$F_{1,vb,Rd,z} = k_{1,z}*\alpha_{b,z}*f_{up}*d*t_p / \gamma_{M2}$

$F_{1,vb,Rd,z}$ = 254.81 [kN] Resistance of an anchor bolt for bearing pressure onto the base plate [6.2.2.(7)]

SHEAR OF AN ANCHOR BOLT

α_b =	0.37		Coeff. for resistance calculation $F_{2,vb,Rd}$	[6.2.2.(7)]
A_{vb} =	201	[mm^2]	Area of bolt section	[6.2.2.(7)]
f_{ub} =	400.00	[MPa]	Tensile strength of the anchor material	[6.2.2.(7)]
γ_{M2} =	1.25		Partial safety factor	[6.2.2.(7)]

$F_{2,vb,Rd} = \alpha_b*f_{ub}*A_{vb}/\gamma_{M2}$

$F_{2,vb,Rd}$ = 23.68 [kN] Shear resistance of a bolt - without lever arm [6.2.2.(7)]

CONCRETE PRY-OUT FAILURE

$N_{Rk,c}$ =	38.34	[kN]	Design uplift capacity	CEB [9.2.4]
k_3 =	2.00		Factor related to the anchor length	CEB [9.3.3]
γ_{Mc} =	2.16		Partial safety factor	CEB [3.2.3.1]

$F_{v,Rd,cp} = k_3*N_{Rk,c}/\gamma_{Mc}$

$F_{v,Rd,cp}$ = 35.50 [kN] Concrete resistance for pry-out failure CEB [9.3.1]

CONCRETE EDGE FAILURE

Shear force $V_{j,Ed,y}$

$V_{Rk,c,y}^0$ =	84.20	[kN]	Characteristic resistance of an anchor	CEB [9.3.4.(a)]
$\psi_{A,V,y}$ =	1.00		Factor related to anchor spacing and edge distance	CEB [9.3.4]
$\psi_{h,V,y}$ =	1.00		Factor related to the foundation thickness	CEB [9.3.4.(c)]

$V_{Rk,c,y}{}^{0}$ =	84.20	[kN]	Characteristic resistance of an anchor	CEB [9.3.4.(a)]
$\psi_{s,V,y}$ =	1.00		Factor related to the influence of edges parallel to the shear load direction	CEB [9.3.4.(d)]
$\psi_{ec,V,y}$ =	1.00		Factor taking account a group effect when different shear loads are acting on the individual anchors in a group	CEB [9.3.4.(e)]
$\psi_{\alpha,V,y}$ =	1.00		Factor related to the angle at which the shear load is applied	CEB [9.3.4.(f)]
$\psi_{ucr,V,y}$ =	1.00		Factor related to the type of edge reinforcement used	CEB [9.3.4.(g)]
γ_{Mc} =	2.16		Partial safety factor	CEB [3.2.3.1]

$F_{v,Rd,c,y} = V_{Rk,c,y}{}^{0} * \psi_{A,V,y} * \psi_{h,V,y} * \psi_{s,V,y} * \psi_{ec,V,y} * \psi_{\alpha,V,y} * \psi_{ucr,V,y} / \gamma_{Mc}$

$F_{v,Rd,c,y}$ =	38.98	[kN]	Concrete resistance for edge failure	CEB [9.3.1]

Shear force $V_{j,Ed,z}$

$V_{Rk,c,z}{}^{0}$ =	6126.75	[kN]	Characteristic resistance of an anchor	CEB [9.3.4.(a)]
$\psi_{A,V,z}$ =	0.00		Factor related to anchor spacing and edge distance	CEB [9.3.4]
$\psi_{h,V,z}$ =	2.45		Factor related to the foundation thickness	CEB [9.3.4.(c)]
$\psi_{s,V,z}$ =	0.71		Factor related to the influence of edges parallel to the shear load direction	CEB [9.3.4.(d)]
$\psi_{ec,V,z}$ =	1.00		Factor taking account a group effect when different shear loads are acting on the individual anchors in a group	CEB [9.3.4.(e)]
$\psi_{\alpha,V,z}$ =	1.00		Factor related to the angle at which the shear load is applied	CEB [9.3.4.(f)]
$\psi_{ucr,V,z}$ =	1.00		Factor related to the type of edge reinforcement used	CEB [9.3.4.(g)]
γ_{Mc} =	2.16		Partial safety factor	CEB [3.2.3.1]

$F_{v,Rd,c,z} = V_{Rk,c,z}{}^{0} * \psi_{A,V,z} * \psi_{h,V,z} * \psi_{s,V,z} * \psi_{ec,V,z} * \psi_{\alpha,V,z} * \psi_{ucr,V,z} / \gamma_{Mc}$

$F_{v,Rd,c,z}$ =	12.90	[kN]	Concrete resistance for edge failure	CEB [9.3.1]

SPLITTING RESISTANCE

$C_{f,d}$ =	0.30		Coeff. of friction between the base plate and concrete	[6.2.2.(6)]
$N_{c,Ed}$ =	0.35	[kN]	Compressive force	[6.2.2.(6)]

$C_{f,d}$ =	0.30		Coeff. of friction between the base plate and concrete	[6.2.2.(6)]

$F_{f,Rd} = C_{f,d}*N_{c,Ed}$

$F_{f,Rd}$ =	0.10	[kN]	Slip resistance	[6.2.2.(6)]

SHEAR CHECK

$V_{j,Rd,y} = n_b*\min(F_{1,vb,Rd,y}, F_{2,vb,Rd}, F_{v,Rd,cp}, F_{v,Rd,c,y}) + F_{f,Rd}$

$V_{j,Rd,y}$ =	94.81	[kN]	Connection resistance for shear	CEB [9.3.1]

$V_{j,Ed,y} / V_{j,Rd,y} \leq 1,0$	0.01 < 1.00	verified	(0.01)

$V_{j,Rd,z} = n_b*\min(F_{1,vb,Rd,z}, F_{2,vb,Rd}, F_{v,Rd,cp}, F_{v,Rd,c,z}) + F_{f,Rd}$

$V_{j,Rd,z}$ =	51.70	[kN]	Connection resistance for shear	CEB [9.3.1]

$V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0$	0.20 < 1.00	verified	(0.20)
$V_{j,Ed,y} / V_{j,Rd,y} + V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0$	0.21 < 1.00	verified	(0.21)

WELDS BETWEEN THE COLUMN AND THE BASE PLATE

$\sigma_\perp$ =	75.86	[MPa]	Normal stress in a weld	[4.5.3.(7)]
$\tau_\perp$ =	75.86	[MPa]	Perpendicular tangent stress	[4.5.3.(7)]
τ_{yII} =	1.21	[MPa]	Tangent stress parallel to $V_{j,Ed,y}$	[4.5.3.(7)]
τ_{zII} =	17.03	[MPa]	Tangent stress parallel to $V_{j,Ed,z}$	[4.5.3.(7)]
β_W =	0.85		Resistance-dependent coefficient	[4.5.3.(7)]

$\sigma_\perp / (0.9*f_u/\gamma_{M2}) \leq 1.0$ (4.1)	0.25 < 1.00	verified	(0.25)
$\sqrt{(\sigma_\perp^2 + 3.0\,(\tau_{yII}^2 + \tau_\perp^2))} / (f_u/(\beta_W*\gamma_{M2})) \leq 1.0$ (4.1)	0.37 < 1.00	verified	(0.37)
$\sqrt{(\sigma_\perp^2 + 3.0\,(\tau_{zII}^2 + \tau_\perp^2))} / (f_u/(\beta_W*\gamma_{M2})) \leq 1.0$ (4.1)	0.26 < 1.00	verified	(0.26)

CONNECTION STIFFNESS

Bending moment $M_{j,Ed,y}$

b_{eff} =	115	[mm]	Effective width of the bearing pressure zone under the flange	[6.2.5.(3)]
l_{eff} =	160	[mm]	Effective length of the bearing pressure zone under the flange	[6.2.5.(3)]

$k_{13,y} = E_c*\sqrt{(b_{eff}*l_{eff})}/(1.275*E)$

$k_{13,y}$ =	12	[mm]	Stiffness coeff. of compressed concrete	[Table 6.11]
l_{eff} =	100	[mm]	Effective length for a single bolt for mode 2	[6.2.6.5]
m =	49	[mm]	Distance of a bolt from the stiffening edge	[6.2.6.5]

$k_{15,y} = 0.425*l_{eff}*t_p^3/(m^3)$

$k_{15,y}$ =	5	[mm]	Stiffness coeff. of the base plate subjected to tension	[Table 6.11]
L_b =	171	[mm]	Effective anchorage depth	[Table 6.11]

$k_{16,y} = 1.6*A_b/L_b$

$k_{16,y}$ =	1	[mm]	Stiffness coeff. of an anchor subjected to tension	[Table 6.11]
$\lambda_{0,y}$ =	0.15		Column slenderness	[5.2.2.5.(2)]
$S_{j,ini,y}$ =	2509.29	[kN*m]	Initial rotational stiffness	[Table 6.12]
$S_{j,rig,y}$ =	7727.61	[kN*m]	Stiffness of a rigid connection	[5.2.2.5]

$S_{j,ini,y} < S_{j,rig,y}$ SEMI-RIGID [5.2.2.5.(2)]

Bending moment $M_{j,Ed,z}$

$k_{13,z} = E_c*\sqrt{(A_{c,z})}/(1.275*E)$

$k_{13,z}$ =	10	[mm]	Stiffness coeff. of compressed concrete	[Table 6.11]
l_{eff} =	100	[mm]	Effective length for a single bolt for mode 2	[6.2.6.5]
m =	49	[mm]	Distance of a bolt from the stiffening edge	[6.2.6.5]

$k_{15,z} = 0.425*l_{eff}*t_p^3/(m^3)$

$k_{15,z}$ =	5	[mm]	Stiffness coeff. of the base plate subjected to tension	[Table 6.11]
L_b =	171	[mm]	Effective anchorage depth	[Table 6.11]

$k_{16,z} = 1.6*A_b/L_b$

$k_{16,z}$ =	1	[mm]	Stiffness coeff. of an anchor subjected to tension	[Table 6.11]
$\lambda_{0,z}$ =	0.15		Column slenderness	[5.2.2.5.(2)]
$S_{j,ini,z}$ =	1490.03	[kN*m]	Initial rotational stiffness	[6.3.1.(4)]
$S_{j,rig,z}$ =	7727.61	[kN*m]	Stiffness of a rigid connection	[5.2.2.5]

$S_{j,ini,z} < S_{j,rig,z}$ SEMI-RIGID [5.2.2.5.(2)]

Connection conforms to the code	Ratio	0.56