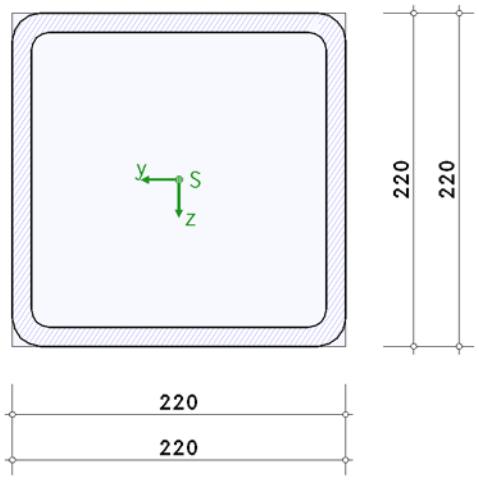
clamped steel support foot

steel code verifications acc. to DIN EN 1993-1:2010-12 with NA-Germany

cross-section, scale 1:5



column cross section
standardized profile: QR 220 x 220 x 12.5(w), of quality S235

base plate
b = 220 mm h = 220 mm t = 10 mm, of quality S235

mortar joint under base plate
h_f = 40 mm

foundation
concrete quality C25/30
height = 100.0 cm
splitting tensile reinforcement is provided

1. loading

1.1. design values of column load

point of application in column centroid

LK	notation	design situat.	$N_{St,d}$ kN	$M_{y,St,Ed}$ kNm	$H_{z,St,Ed}$ kN	$M_{z,St,Ed}$ kNm	$H_{y,St,Ed}$ kN
1	new design load c.	perman. a.v.	98.00	164.00	63.00	0.00	0.00

2. verification

2.1. partial safety factors for material

design situat.	γ_{M0}	γ_{M2}	γ_c
perman.	1.00	1.25	1.50

2.2. clamping depth

determination of the required clamping depth acc. to [1]

2.2.1. required clamping depth for bending around the y-axis

coefficient of the contributing width	α_m	= 1.00
contributing width	b_m	= 139.3 mm
resulting pressure	p	= 19.73 kN/cm
perm. plastic shear force	$V_{pl,z}$	= 692.45 kN

required clamping depth

LK	D_o kN	D_u kN	$D_u/V_{pl,z}$ -	f_{erf} cm
1	533.82	470.82	0.68	**62.9**

D_o/D_u - res. compressive force top/bottom f_{erf} - req. clamping depth

maximum required clamping depth for bending around the y-axis $f_{erf,y}$ = 62.9 cm

2.2.2. set clamping depth

required	f_{erf}	=	62.9 cm	(from LK 1, Bieg. um y-Achse)
minimum value	f_{min} = 1.5·22.00	=	33.0 < 62.9 cm	
maximum value	f_{max} = 4.0·22.00	=	88.0 > 62.9 cm	
chosen	**f_{gew}**	=	**63.0** > 62.9 cm	

2.3. resistance of cross section

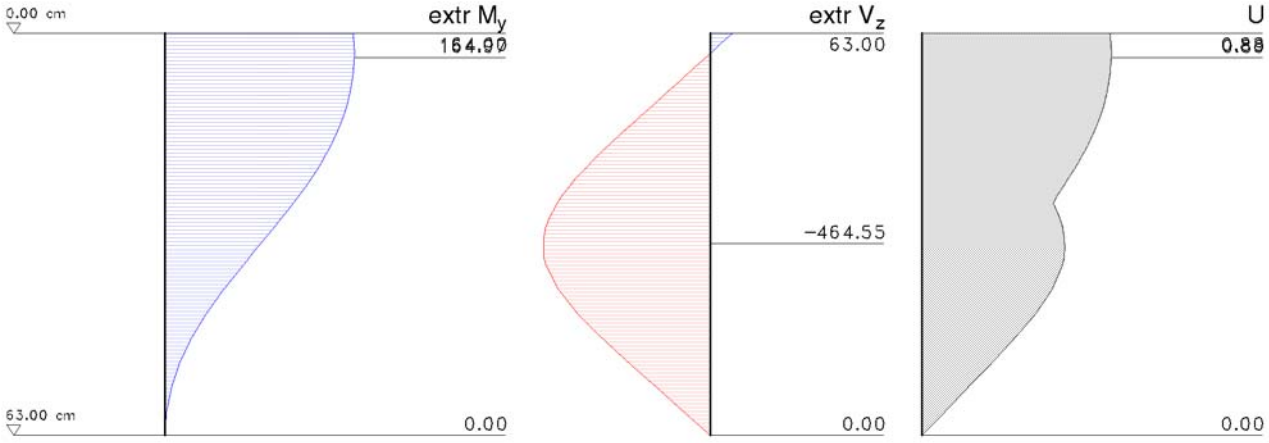
plastic stress analysis is carried out acc. to [2], Abs. 6.2.2 to 6.2.10.

2.3.1. supporting forces

LK	My/Vz			
	a_o	a_u	D_o	D_u
	cm	cm	kN	kN
1	33.0	29.1	528.14	465.14

a_o/a_u - pressure area top/bottom D_o/D_u - res. compressive force top/bottom

2.3.2. extreme internal forces and moments



extreme values of axial force: N_{Min} / N_{Max} = 98.00 / 98.00 kN

x	extr My		extr Vz		U
	Min	Max	Min	Max	
cm	kNm	kNm	kNm	kNm	
0.00	164.00	164.00	63.00	**63.00**	0.88
2.54	164.96	164.96	12.84	12.84	0.89
3.81	164.97	**164.97**	-12.23	-12.23	**0.89**
26.69	111.69	111.69	-427.18	-427.18	0.62
33.05	82.99	82.99	**-464.55**	-464.55	0.67
63.00	**0.00**	0.00	0.00	0.00	0.00

maximum utilization U = 0.89 < 1.00

from load spectrum 1 at the location x = 2.54 cm

internal forces and moments: N = 98.00 kN, V_z/M_y = 12.84/164.96 kNm

utilization: U_σ = 0.89

2.4. weld between column and base plate

design with direction oriented method acc. to clause 4.5.3.2

$\sigma_{1,w,Ed} = (\sigma_\perp^2+3\cdot\tau_\perp^2+3\cdot\tau_{||}^2)^{0.5}$

$\sigma_{2,w,Ed} = \sigma_\perp$

$f_{1,w,Rd} = f_u/(\beta_w\cdot\gamma_{M2})$

$f_{2,w,Rd} = 0.9\cdot f_u/\gamma_{M2}$

$U = \max\{ \sigma_{1,w,Ed}/f_{1,w,Rd}, \sigma_{2,w,Ed}/f_{2,w,Rd} \}$

connection designed with a **circumferential fillet weld.**

axial force transfer of 100 % by the weld.

minimum value of the weld thickness a_{min} = 3 mm

LK	a_w	$\sigma_\perp$	$\tau_\perp$	$\tau_{||}$	$\sigma_{1,w,Ed}$	$f_{1,w,Rd}$	$\sigma_{2,w,Ed}$	$f_{2,w,Rd}$	U
	mm	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	-
1	**3**	-28.13	-28.13	0.00	56.26	360.00	28.13	259.20	**0.16**

a_w - weld thickness $\sigma_\perp$ - normal stresses perpendicular to weld $\tau_\perp$ - shear stresses perpendicular to weld
$\tau_{||}$ - shear stresses parallel to weld U - utilization

maximum weld thickness $a_{w,max}$ = 3 mm

maximum utilization U = 0.16 < 1.00

2.5. introduction of the normal force into the foundation

verification acc. to [4], parag. 6.2.5 and load-bearing capacity of the subareas acc. to [3], parag.6.7

2.5.1. requirements for the mortar under the base plate

0.2-fold of the smallest panel dimension = 44.0 > 40 mm mortar height

⇒ the characteristic strength of the mortar should be at least 20% of the foundation concrete.

2.5.2. load spreading

$c = t\cdot[f_y/(3\cdot f_{jd}\cdot\gamma_{M0})]^{0.5} \le 0.5\cdot(h-2\cdot t)$

an undisturbed load propagation is assumed.

spreading width	c	= 16.6 mm
loading area	A_{c0}	= 135.26 cm²
distribution area	A_{c1}	= 2916.00 cm²

2.5.3. design resistance

$F_{C,Rdr} = f_{jd}\cdot A_{c0}$

$f_{jd} = \beta_j\cdot F_{Rdu}/A_{c0}$

$F_{Rdu} = A_{c0}\cdot f_{cd}\cdot(A_{c1}/A_{c0})^{0.5} \le 3.0\cdot f_{cd}\cdot A_{c0}$

joint coefficient	β_j	= 2/3
design value of the mortar strength	f_{jd}	= 28.33 N/mm²
load-bearing capacity under pressure	$F_{C,Rd}$	= 383.24 kN

2.5.4. utilization

$U = N_{Ed}/F_{C,Rd}$

maximum compressive force (LK 1) N_{Ed} = 98.00 < 383.24 kN

utilization U = 0.26 < 1.00

3. summary

all executed verifications and design calculations successful.

required clamping depth of the column cross section	f_{erf}	= 62.9 cm
chosen clamping depth	f_{gew}	= 63.0 > 62.9 cm
load-bearing cap. column cross-section	μ_{max}	= 0.89
weld between column and base plate	μ_{max}	= 0.16
introd. of normal force	μ_{max}	= 0.26

literature and standards:

[1] Kindmann, Kraus, Laumann, Vette: Verallgem. Berech.methode für in Beton eingesp. Stahlprofile, Stahlbau 92, Heft 1, Ernst & Sohn, 2023
[2] DIN EN 1993-1-1: Eurocode 3: Bem. und Konstr. von Stahlbauten - Teil 1-1: Allg. Bem.regeln u. Regeln für den Hochbau, Dez. 2010
[3] DIN EN 1992-1-1: Eurocode 2: Bemessung und Konstruktion von Stahlbeton- und Spannbetontragwerken, Teil 1-1, Januar 2011
[4] DIN EN 1993-1-8: Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-8: Bemessung von Anschlüssen, Dez. 2010