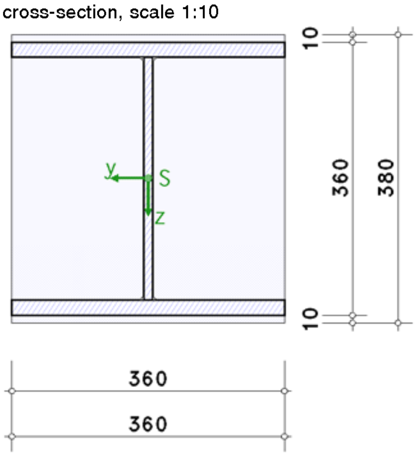
POS. 10: EX. FOR DESIGN ACC. TO EC3, 1.9

4H-EC3KF version: 4/2024-1d

clamped steel support foot

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

cross-section, scale 1:10



column cross section with clamping depth f = 80.0 cm
not standardized I-profile, of quality S275
h = 360.0 mm b = 360.0 mm t_w = 12.0 mm t_f = 20.0 mm
fillet weld a_w = 4.0 mm

base plate
b = 360 mm h = 380 mm t = 12 mm, of quality S275

mortar joint under base plate
h_f = 50 mm

foundation
concrete quality C20/25
distribution area $A_{c1} = 2.25 \cdot A_{c0}$
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	2	perman. a.v.	434.50	233.10	24.60	0.00	0.00
2	3	perman. a.v.	453.50	79.10	0.00	45.70	6.20
3	6	perman. a.v.	309.30	-153.30	-28.10	76.10	10.40

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]

friction coefficient for sand-cement mortar $C_{f,d}$= 0.20
design value of the composite load-bearing capacity τ_{Rd}= 0.30 N/mm²

the lower resulting compressive force is limited to $D_u = 0.80 \cdot V_{pl}$
the composite stresses are taken into account in the relevant direction.

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

the increased permissible concrete pressure is assumed to be $\sigma_{Rdu} = f_{cd} \cdot 2^{0.5}$ = 16.03 N/mm²

length c (acc. to [1], figure 4 and 5) c = 58.6 mm
contributing width b_m = 261.8 mm
resulting pressure p = 41.95 kN/cm
perm. plastic shear force $V_{pl,z}$ = 609.68 kN

required clamping depth

LK	compound tension	D_o kN	D_u kN	$D_u/V_{pl,z}$ -	f_{erf} cm
1	ys	512.35	487.75	0.80	**49.2**
2	no	383.18	383.18	0.63	22.6
3	no	515.85	487.75	0.80	36.2

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

maximum required clamping depth for bending around the y-axis $f_{erf,y}$ = 49.2 cm

2.2.2. required clamping depth for bending around the z-axis

the increased permissible concrete pressure is assumed to be $\sigma_{Rdu} = f_{cd} \cdot 3^{0.5}$ = 19.63 N/mm²

length c (acc. to [1], figure 4 and 5)	c	=	52.9 mm
contributing width	h_m	=	40.0 mm
resulting pressure	p	=	7.85 kN/cm
perm. plastic shear force	$V_{pl,y}$	=	2286.31 kN

required clamping depth

LK	compound tension	D_o kN	D_u kN	$D_u/V_{pl,y}$ -	f_{erf} cm
1	no	0.00	0.00	0.00	0.0
2	ys	126.84	120.64	0.05	38.9
3	ys	175.34	164.94	0.07	**53.5**

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

maximum required clamping depth for bending around the z-axis $f_{erf,z}$ = 53.5 cm

2.2.3. set clamping depth

required	f_{erf}	=	53.5 cm	(from LK 3, bend. around z-axis)
minimum value	$f_{min} = 1.5 \cdot 36.00$	=	54.0 > 53.5 cm	
maximum value	$f_{max} = 4.0 \cdot 36.00$	=	144.0 > 53.5 cm	
chosen	f_{gew}	=	**80.0** > 54.0 cm	

2.3. resistance of cross section

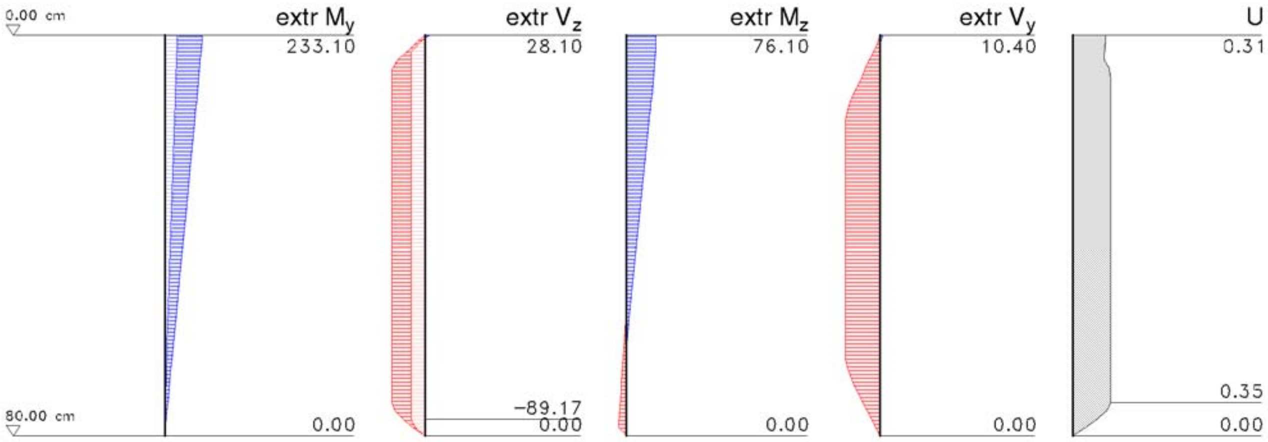
plastic stress analysis is carried out acc. to [2], Abs. 6.2.2 to 6.2.10.

2.3.1. supporting forces

LK	M_y/V_z a_o cm	a_u cm	D_o kN	D_u kN	M_z/V_y a_o cm	a_u cm	D_o kN	D_u kN
1	7.0	6.3	238.27	213.67	---	---	---	---
2	2.4	2.4	81.04	81.04	10.1	9.1	63.98	57.78
3	5.9	5.1	201.66	173.56	18.2	16.6	115.81	105.41

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} = 309.30 / 453.50 kN

x cm	extr My Min kNm	extr My Max kNm	extr Vz Min kNm	extr Vz Max kNm	extr Mz Min kNm	extr Mz Max kNm	extr Vy Min kNm	extr Vy Max kNm	U
0.00	79.10	**233.10**	0.00	**28.10**	0.00	**76.10**	0.00	**10.40**	0.31
1.66	76.27	230.36	-61.95	-41.35	0.00	75.27	-6.80	0.00	0.30
3.31	73.88	226.47	-114.10	-89.17	0.00	74.22	-19.80	0.00	0.30
4.97	72.18	221.79	-175.03	-89.17	0.00	72.96	-32.71	0.00	0.29
8.28	68.80	213.37	**-214.28**	-89.17	0.00	69.79	-54.58	0.00	**0.35**
18.21	58.66	183.50	-214.28	-89.17	0.00	56.85	**-105.01**	0.00	0.35
63.43	12.48	47.54	-214.28	-89.17	-6.76	0.00	-105.01	0.00	0.35
75.03	0.63	13.34	-193.49	-89.17	-16.93	0.00	-39.08	0.00	0.32
76.69	-1.06	8.52	-140.08	-89.17	-18.37	0.00	-26.07	0.00	0.23
78.34	**-3.45**	4.24	-75.72	-61.96	**-19.59**	0.00	-13.05	0.00	0.12
80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

maximum utilization U = 0.35 < 1.00

from load spectrum 1 at the location x = 8.28 cm

internal forces and moments: N = 434.50 kN, V_z/M_y = -214.28/213.37 kNm, V_y/M_z = 0.00/0.00 kNm
utilization: U_σ = 0.35

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 **full-size double fillet weld** (no end craters).
weld thickness at the **flange 4 mm** and at the **web 4 mm.**
axial force transfer of 100 % by the weld.

minimum value of the flange weld thickness $a_{w,Fl,min}$ = 4.0 = 4.0 mm
minimum value der web weld thickness $a_{w,S,min}$ = 3.0 < 4.0 mm

LK	$\sigma_\perp$ N/mm²	$\tau_\perp$ N/mm²	τ_{II} N/mm²	$\sigma_{1,w,Ed}$ N/mm²	$f_{1,w,Rd}$ N/mm²	$\sigma_{2,w,Ed}$ N/mm²	$f_{2,w,Rd}$ N/mm²	U -
1	-38.20	-38.20	0.00	76.40	404.71	38.20	309.60	0.19
2	-39.87	-39.87	0.00	79.74	404.71	39.87	309.60	**0.20**
3	-27.19	-27.19	0.00	54.38	404.71	27.19	309.60	0.13

$\sigma_\perp$ - normal stresses perpendicular to weld $\tau_\perp$ - shear stresses perpendicular to weld τ_{II} - shear stresses parallel to weld
U - utilization

maximum utilization U = 0.20 < 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 = 72.0 > 50 mm mortar height
⇒ the characteristic strength of the mortar should be at least 20% of the foundation concrete.

2.5.2. load spreading

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

spreading width c = 34.1 mm
loading area A_{c0} = 663.76 cm²
the distribution area is assumed to A_{c1} = $2.25\cdot A_{c0}$

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} = 11.33 N/mm²
load-bearing capacity under pressure $F_{C,Rd}$ = 752.26 kN

2.5.4. utilization

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

maximum compressive force (LK 2) N_{Ed} = 453.50 < 752.26 kN

utilization U = 0.60 < 1.00

3. summary

all executed verifications and design calculations successful.

chosen clamping depth of the column cross-sect.	f_{gew}	= 80.0 cm
required clamping depth	f_{erf}	= 53.5 < 80.0 cm
load-bearing cap. column cross-section	μ_{max}	= 0.35
weld between column and base plate	μ_{max}	= 0.20
introd. of normal force	μ_{max}	= 0.60

literature and standards:

[1] R. Kindmann, J. Laumann: Erf. Einspanntiefen von Stahlstuetzen in Betonfundamenten, Stahlbau 74, Heft 8, Ernst & Sohn, 2005
[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