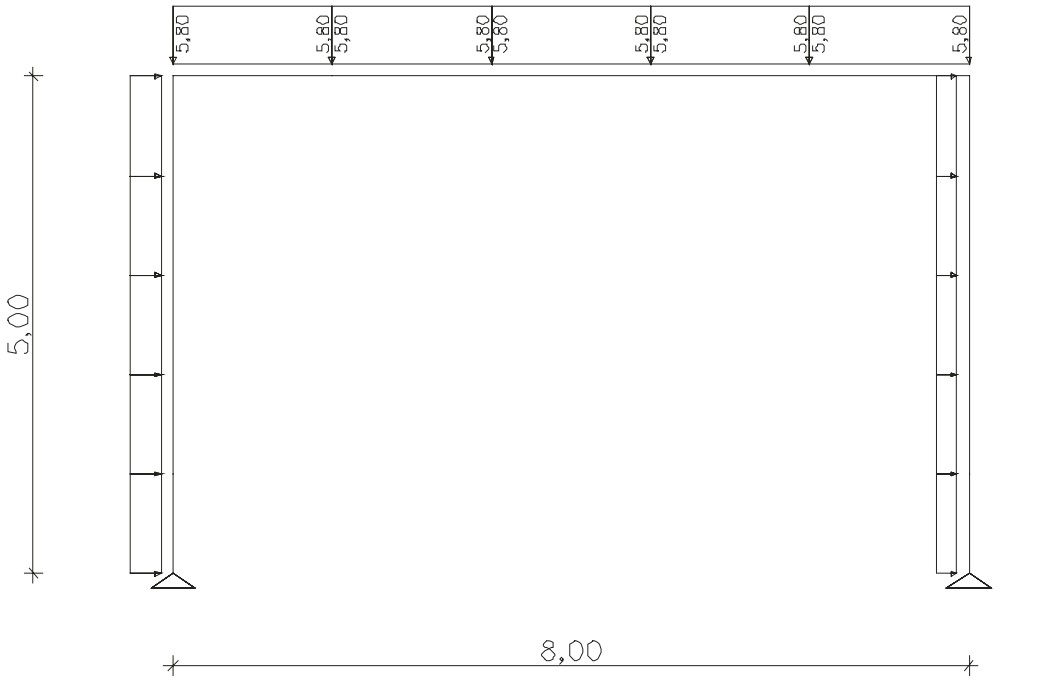
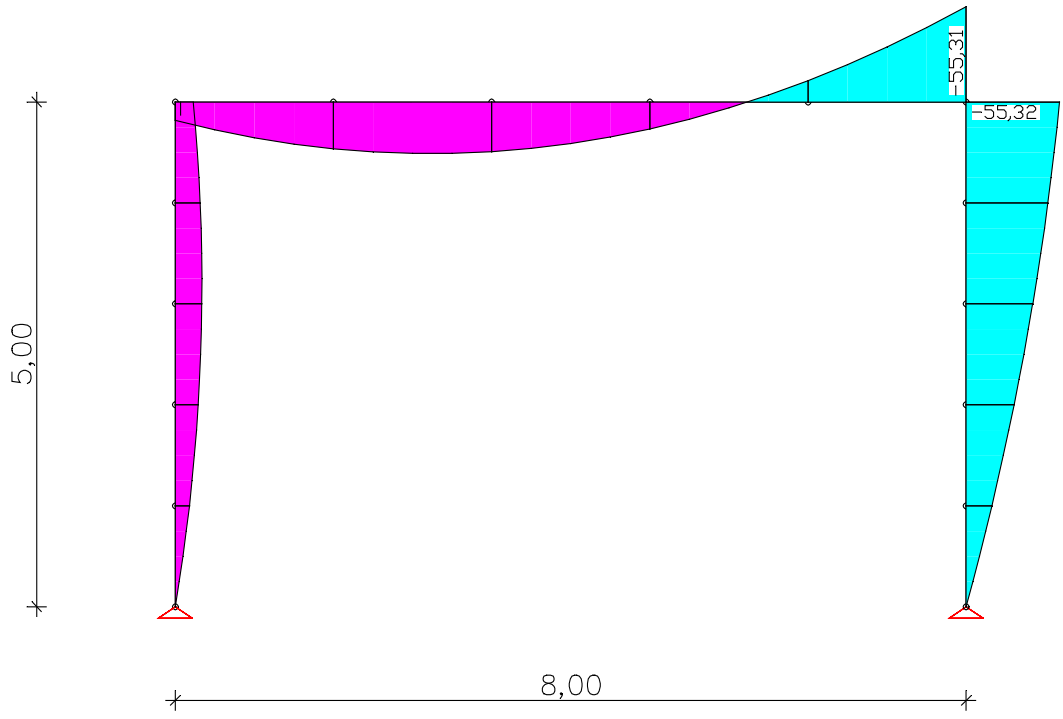
## Zweigelenkrahmen

Beispiel 2b aus:

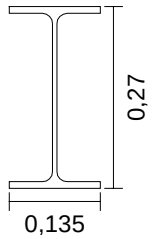
ζ - Werte für den Biegedrillknicknachweis von I-Profilen, Martin, Leipzig Annual Civil Engineering Report No. 1,  1996



## Protokollausdruck:

### Querschnitt: IPE 270




h = 270,0 mm
b = 135,0 mm
s = 6,6 mm
t = 10,2 mm
r = 15,0 mm

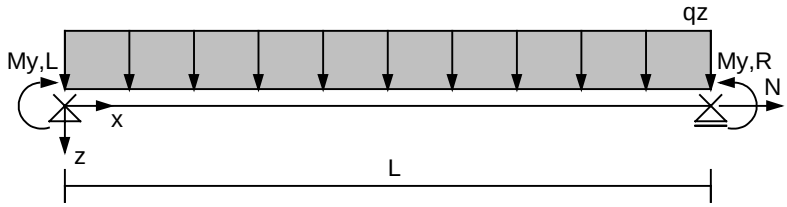
A = 45,9 cm² $I_y$ = 5790,0 cm⁴ $I_z$ = 420,0 cm⁴
$I_T$ = 16,0 cm⁴ $I_\omega$ = 70580 cm⁶
$i_z$ = 3,02 cm $i_p$ = 11,63 cm $i_M$ = 11,63 cm

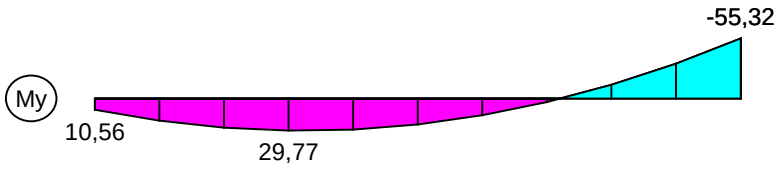
### Material: S235

$f_{y,k}$ = 240 N/mm²
E-Modul = 210000 N/mm²
G-Modul = 81000 N/mm²
$\gamma_M$ = 1,10

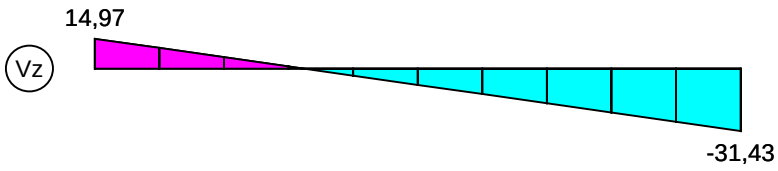
### Einwirkungen in z-Richtung

L = 8,00 m $N_d$ = 0,00 kN $q_{z,d}$ = 5,80 kN/m
$M_{y,d,links}$ = 10,56 kNm $M_{y,d,rechts}$ = -55,32 kNm
Lastangriffspunkt Schubmittelpunkt ⇒ $z_p$ = 0,00 cm
Die Stabenden sind Gabelgelagert.

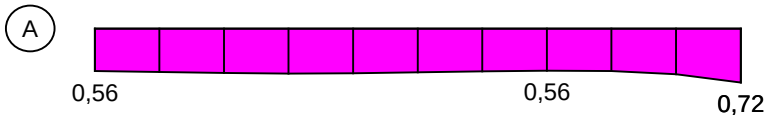



Max My,d = 29,77 kNm, Min My,d = -55,32 kNm




Max Vz,d = 14,97 kN, Min Vz,d = -31,43 kN




Max Ausnutzung = 0,72

**Knicklast $N_{Ki,z,d}$**

$N_{Ki,z,d} = \pi^2 \cdot (E \cdot I_z / \gamma_M) / L^2$

mit $I_z$ = 420,0 cm$^4$ E = 210000 N/mm²

L = 8,00 m $\gamma_M$ = 1,1

$N_{Ki,z,d}$ = 123,65 kN

**Verzweigungslastfaktor $\eta_{Ki,y}$ für $M_{Ki,y,d}$**

$\eta_{Ki,y}$ = 1,97

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**Maßgebender Nachweis an der Stelle x = 8,00 m**

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**Schnittgrößen:**

$N_d$ = 0,00 kN

$V_{z,d}$ = -31,43 kN

$M_{y,d}$ = -55,32 kNm

**Plastische Schnittgrößen:**

$N_{pl,k}$ = ± 1101,60 kN $N_{pl,d}$ = ± 1001,45 kN

$V_{pl,z,k}$ = ± 228,26 kN $V_{pl,z,d}$ = ± 207,51 kN

$M_{pl,y,k}$ = ± 116,16 kNm $M_{pl,y,d}$ = ± 105,60 kNm

**Abminderungsfaktor $\kappa_z$**

$\bar{\lambda}_{k,z} = \sqrt{N_{pl,d} / N_{Ki,z,d}}$

mit $N_{pl,d}$ = 1001,45 kN $N_{Ki,z,d}$ = 123,65 kN

$\bar{\lambda}_{k,z}$ = 2,85 > 0,2

$\kappa_z = 1/(k + \sqrt{k^2 - \bar{\lambda}_{k,z}^2})$ $k = 0{,}5 \cdot (1 + \alpha \cdot (\bar{\lambda}_{k,z} - 0{,}2) + \bar{\lambda}_{k,z}^2)$

Knickspannungslinie b $\Rightarrow \alpha$ = 0,34

k = 5,00

$\kappa_z$ = 0,11

**Biegedrillknickmoment $M_{Ki,y,d}$**

$$M_{Ki,y,d} = \frac{\eta_{Ki,y} \cdot M_{y,d}}{\gamma_M}$$

mit $\eta_{Ki} = 1{,}97$ $M_{y,d} = -55{,}32$ kNm $\gamma_M = 1{,}1$

$M_{Ki,yd} = -98{,}85$ kNm

**Abminderungsfaktor $\kappa_M$**

$\bar{\lambda}_M = \sqrt{M_{pl,y,d} / M_{Ki,y,d}}$

mit $M_{pl,y,d} = -105{,}60$ kNm $M_{Ki,y,d} = -98{,}85$ kNm

$\bar{\lambda}_M = 1{,}03 > 0{,}4$

$\kappa_M = (1/(1+\bar{\lambda}_M^{2 \cdot n}))^{1/n}$

Momentenverhältnis $\psi = -0{,}19 \leq 0{,}5$

Faktor $K_n = 1{,}00$

Beiwert für gewalzte Träger $n = 2{,}50 \Rightarrow n_{red} = n \cdot K_n = 2{,}50$

$\kappa_M = 0{,}73$

**Beiwert $k_y$**

$k_y = 1 - N_d / (\kappa_z \cdot N_{pl,d}) \cdot a_y \leq 1$ $a_y = 0{,}15 \cdot \bar{\lambda}_{k,z} \cdot \beta_{M,y} - 0{,}15 \leq 0{,}9$

mit $N_d = 0{,}00$ kN $N_{pl,d} = 1001{,}45$ kN

$\kappa_z = 0{,}11$ $\bar{\lambda}_{k,z} = 2{,}85$

Momentenverhältnis $\psi_{,y} = -0{,}19 \Rightarrow \beta_{M,y} = 1{,}59$

$a_y = 0{,}53$

$k_y = 1{,}00$

**Nachweis**

$$\frac{N_d}{\kappa_z \cdot N_{pl,d}} + \frac{M_{y,d}}{\kappa_M \cdot M_{ply,d}} \cdot k_y \leq 1$$

$N_d = 0{,}00$ kN $M_{y,d} = -55{,}32$ kNm

$N_{pl,d} = 1001{,}45$ kN $M_{ply,d} = -105{,}60$ kNm

$\kappa_z = 0{,}11$ $\kappa_M = 0{,}73$ $k_y = 1{,}00$

**0,00 + 0,72 = 0,72 ≤ 1.0 Nachweis erfüllt !**