

Diethard Thieme

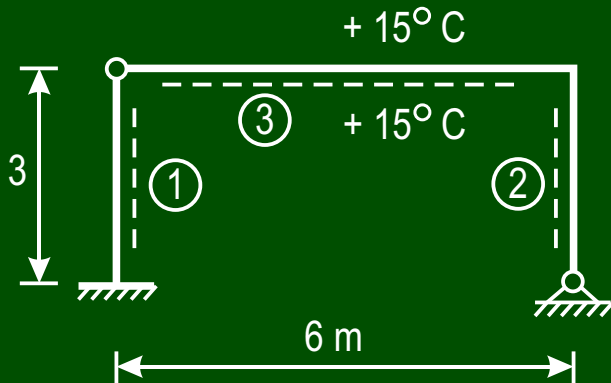
Übungen

zur

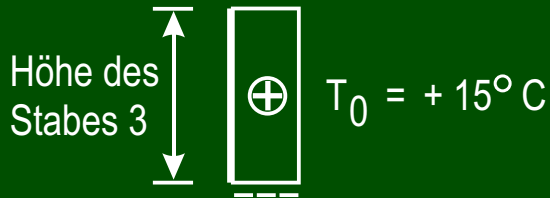
Baustatik

BS 10

DIE AUFGABEN IN BS03 GERECHNET ?



Temperaturänderung
in Stab 3



Kennwerte

$$J_3 = 300\,000\text{ cm}^4 ; J_1 = J_2 = 0,9 J_3$$

$$E_1 = E_2 = E_3 = 3 \cdot 10^7\text{ kN/m}^2$$

Gleichmäßige Erwärmung des Stabes 3

$$T_0 = +15^\circ\text{C}$$

$$\alpha_t = 1,2 \cdot 10^{-5}\text{ Grad}^{-1}$$

$$\text{Gewählt: } J_0 = J_1 ; E_0 = E_1$$

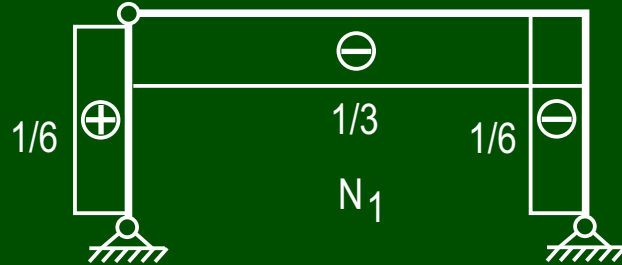
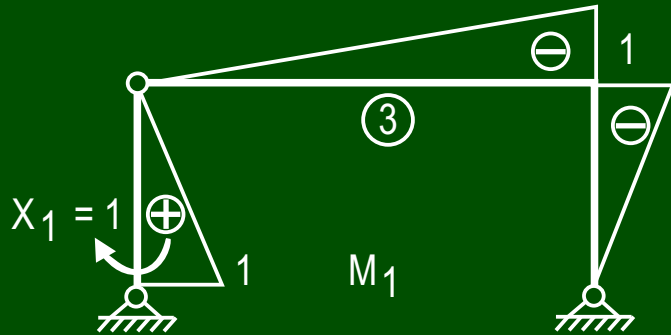
$$E_0 J_0 \alpha_t = 0,972\text{ kN} \cdot \text{m}^2 \cdot \text{Grad}^{-1}$$

Reduzierte Stablängen

$$L'_1 = L'_2 = 3 \frac{1}{1} \frac{1}{1} = 3\text{ m}$$

$$L'_3 = 6 \frac{1}{1} \frac{0,9}{1} = 5,4\text{ m}$$

$$L_3^{(4)} = L_3 E_0 J_0 \alpha_t = 5,832\text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1}$$



$$L'_1 = L'_2 = 3 ; L'_3 = 5,4 ; L_3^{(4)} = 5,832$$

$$a = E_0 J_0 1^* \delta$$

Belastungszahl

$$a_{10} = 5,832 (+15) \left(-\frac{1}{3}\right) = -29,2$$

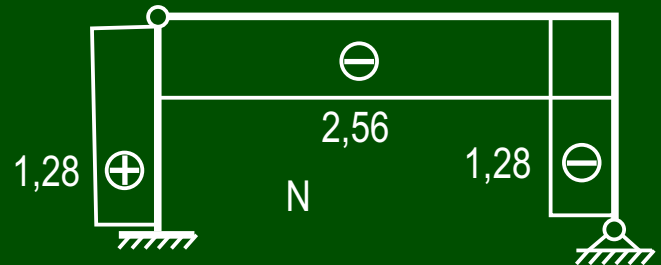
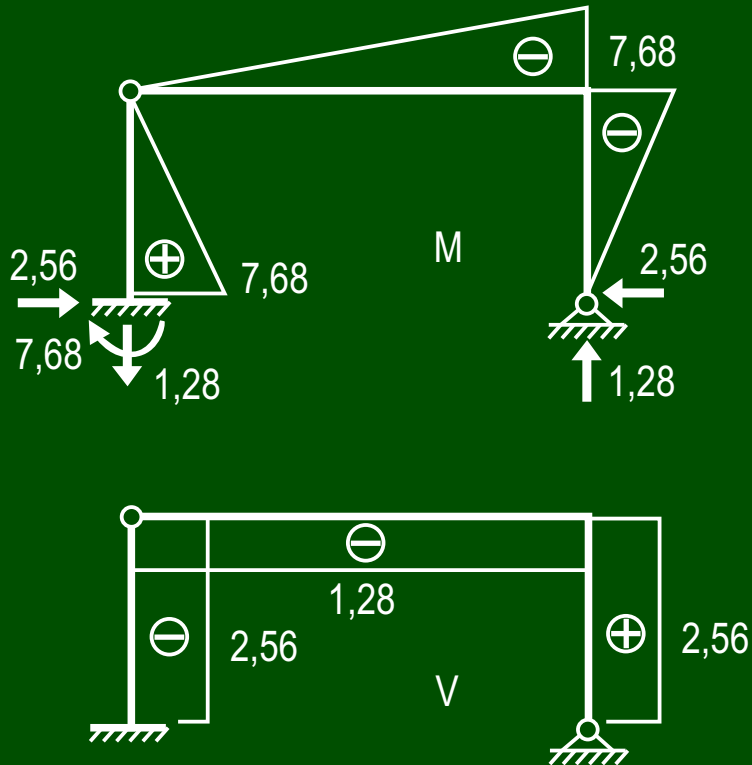
aus T_0 und N_1 in Stab 3

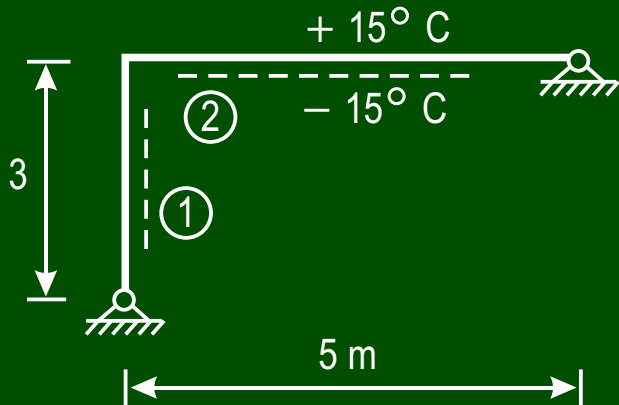
Vorzahl

$$a_{11} = 3 \frac{1}{3} 1^2 + 3 \frac{1}{3} (-1)^2 + 5,4 \frac{1}{3} (-1)^2 = 3,8$$

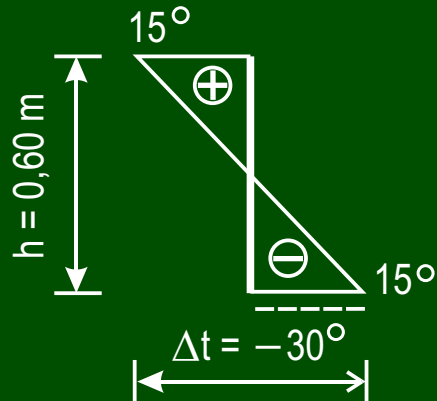
Gleichung

$$a_{11} X_1 = -a_{10} \text{ daraus } X_1 = 7,68$$





Temperaturänderung im Stab 2



Kennwerte

$$J_1 = 600\,000 \text{ cm}^4 ; J_2 = 1,2 J_1$$

$$E_1 = E_2 = 3 \cdot 10^7 \text{ kN/m}^2$$

Querschnitt des Stabes 2 : 40/60 cm

Temperaturänderung im Stab 2

Erwärmung außen um $+15^\circ \text{C}$

Abkühlung innen um -15°C

$$\alpha_t = 1,2 \cdot 10^{-5} \text{ Grad}^{-1}$$

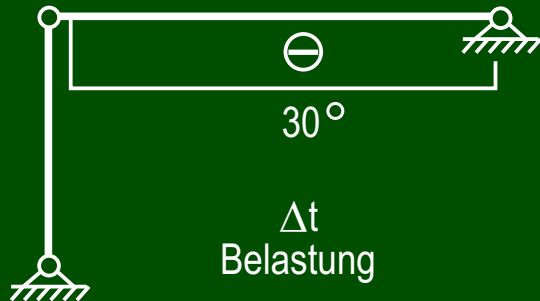
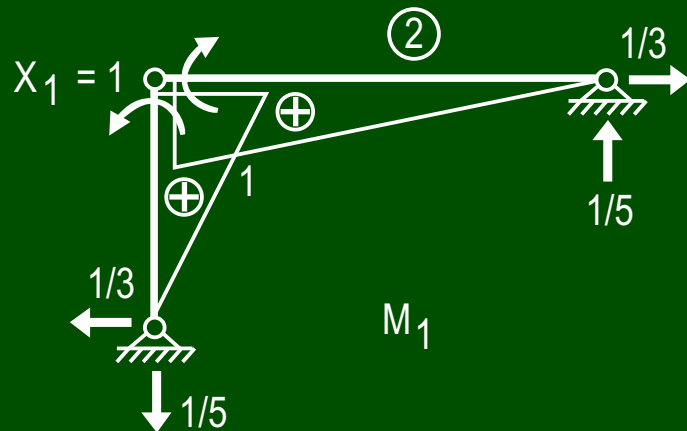
$$\text{Gewählt: } J_0 = J_1 ; E_0 = E_1$$

$$E_0 J_0 \alpha_t = 2,16 \text{ kN} \cdot \text{m}^2 \cdot \text{Grad}^{-1}$$

Reduzierte Stablängen

$$L'_1 = 3 \text{ m} ; L'_2 = 4,17 \text{ m}$$

$$L_2^{(4)} = L_2 E_0 J_0 \alpha_t = 10,6 \text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1}$$



$$L'_1 = 3 ; L'_2 = 4,17 ; L_2^{(4)} = 10,8$$

$$a = E_0 J_0 1^* \delta$$

Belastungszahl

$$a_{10} = 10,8 \frac{1}{2} 1 \left(\frac{-30}{0,6} \right) = -270$$

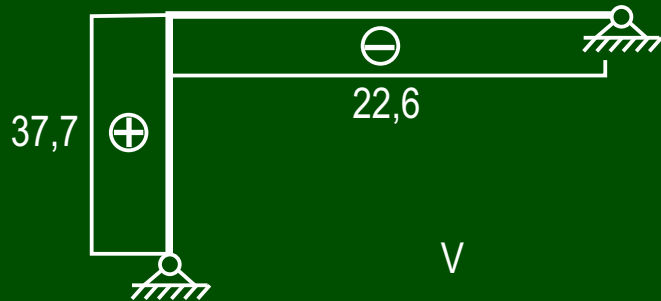
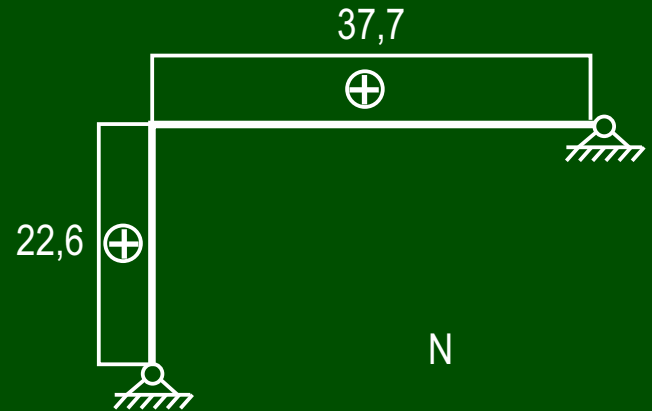
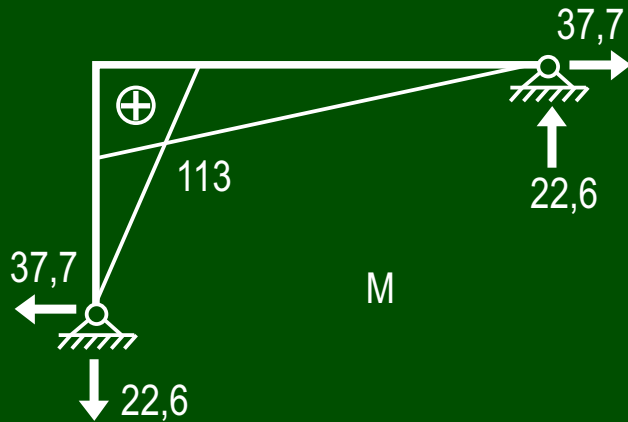
aus Δt und M_1 in Stab 2

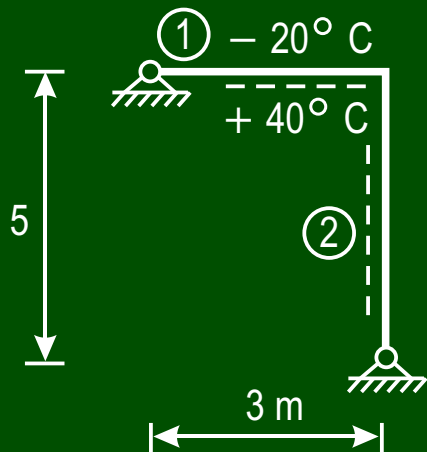
Vorzahl

$$a_{11} = 3 \frac{1}{3} 1^2 + 4,17 \frac{1}{3} 1^2 = 2,39$$

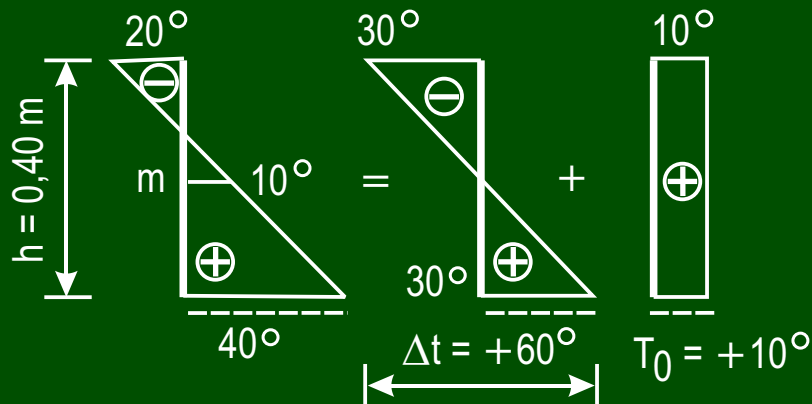
Gleichung

$$a_{11} X_1 = -a_{10} \text{ daraus } X_1 = 113$$





Temperaturänderung im Stab 2



Kennwerte

$$J_2 = 102\,400 \text{ cm}^4 ; J_1 = 1,25 J_2$$

$$E_1 = E_2 = 2,1 \cdot 10^7 \text{ kN/m}^2$$

Stabhöhe des Stabes 2 : $h = 40 \text{ cm}$

Temperaturänderung im Stab 2

Abkühlung außen um -20°C

Erwärmung innen um $+40^\circ \text{C}$

$$\alpha_t = 1,2 \cdot 10^{-5} \text{ Grad}^{-1}$$

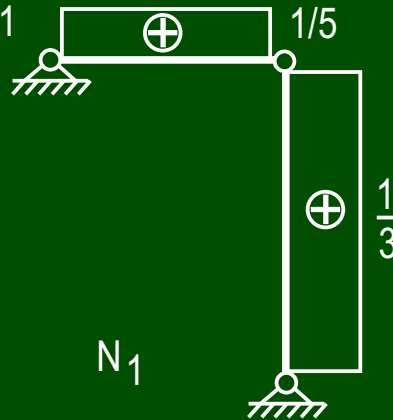
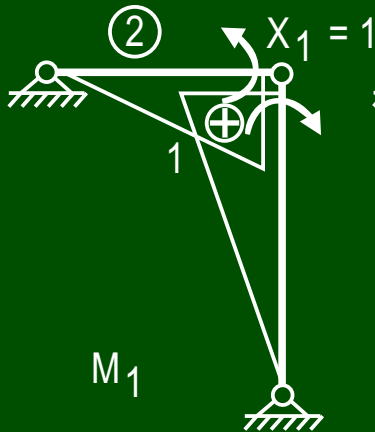
Gewählt: $J_0 = J_1 ; E_0 = E_1$

$$E_0 J_0 \alpha_t = 0,323 \text{ kN} \cdot \text{m}^2 \cdot \text{Grad}^{-1}$$

Reduzierte Stablängen

$$L'_1 = 5 \text{ m} ; L'_2 = 3,75 \text{ m}$$

$$L_2^{(4)} = 0,969 \text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1}$$



$$L'_1 = 5 ; L'_2 = 3,75 ; L_2^{(4)} = 0,969$$

$$a = E_0 J_0 1^* \delta$$

Belastungszahl

$$a_{10} = 0,969 \frac{1}{2} 1 \frac{60}{0,40} +$$

$$\text{aus } \Delta t \text{ und } M_1 \text{ in Stab 2} \\ + 0,969 \frac{1}{5} 10 = 74,6$$

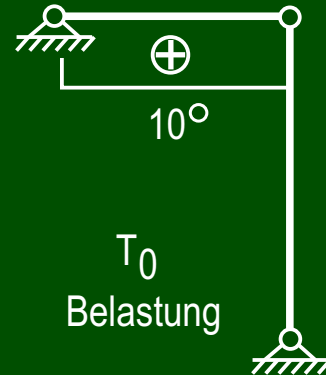
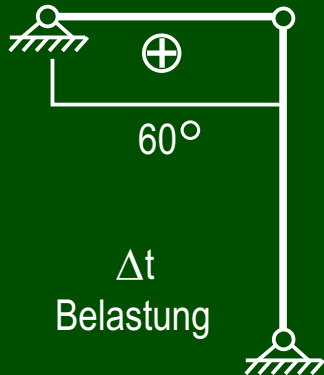
aus T_0 und N_1 in Stab 2

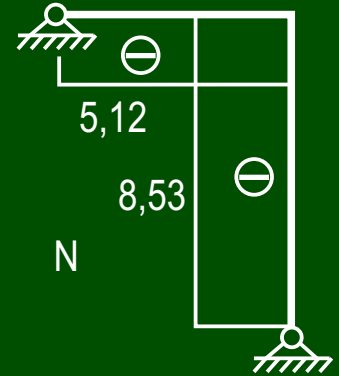
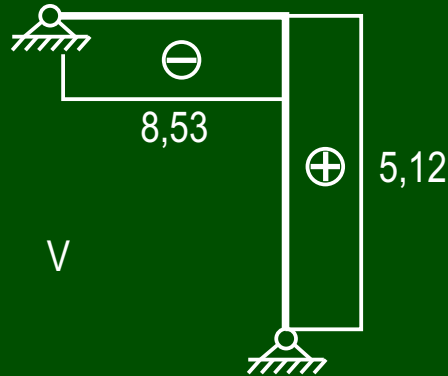
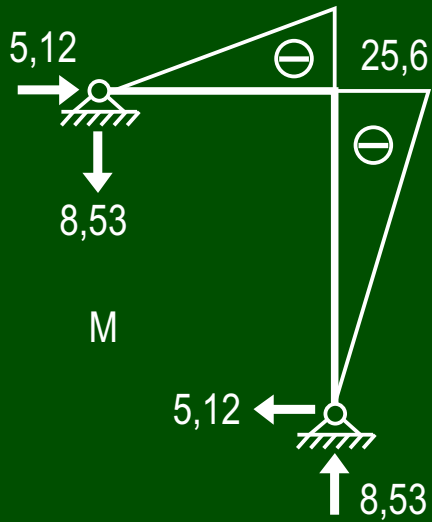
Vorzahl

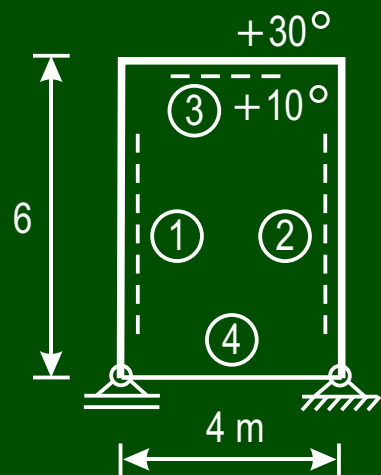
$$a_{11} = 5 \frac{1}{3} 1^2 + 3,75 \frac{1}{3} 1^2 = 2,92$$

Gleichung

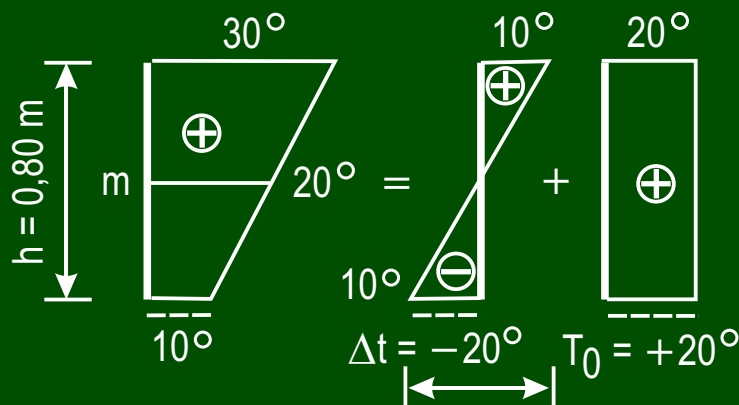
$$a_{11} X_1 = -a_{10} \text{ daraus } X_1 = -25,6$$







Temperaturänderung im Stab 3



Kennwerte

$$J_3 = 1\,280\,000 \text{ cm}^4 ; J_1 = J_2 = 0,75 J_3$$

$$E_1 = E_2 = E_3 = 2,1 \cdot 10^7 \text{ kN/m}^2$$

$$E_4 = 2,1 \cdot 10^8 \text{ kN/m}^2 ; A_4 = 5 \text{ cm}^2$$

Querschnitt des Stabes 3 : 30/80 cm

Temperaturänderung im Stab 3

Erwärmung außen um $+30^\circ \text{ C}$

Erwärmung innen um $+10^\circ \text{ C}$

$$\alpha_t = 1,2 \cdot 10^{-5} \text{ Grad}^{-1}$$

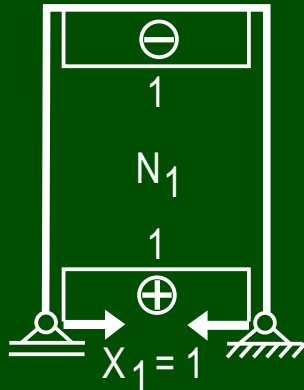
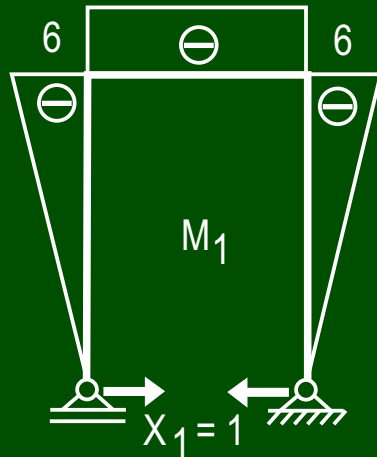
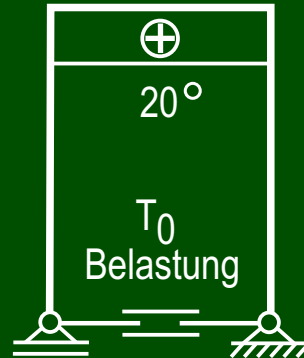
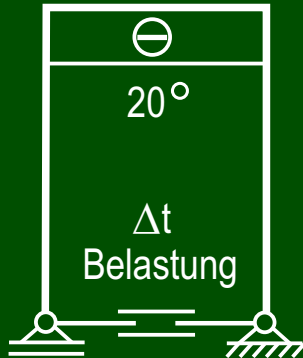
$$\text{Gewählt: } J_0 = J_3 ; E_0 = E_1$$

$$E_0 J_0 \alpha_t = 3,226 \text{ kN} \cdot \text{m}^2 \cdot \text{Grad}^{-1}$$

Reduzierte Stablängen

$$L'_1 = L'_2 = 8 \text{ m} ; L'_3 = 4 \text{ m} ; L''_4 = 10,24 \text{ m}^3$$

$$L_4^{(4)} = 12,9 \text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1}$$



$$L'_1 = L'_2 = 8 \quad ; \quad L'_3 = 4$$

$$L''_4 = 10,24 \quad ; \quad L^{(4)}_3 = 12,9$$

$$a = E_0 J_0 1^* \delta$$

Belastungszahl

aus Δt

aus T_0

$$a_{10} = 12,9 \left[(-6) \left(\frac{-20}{0,8} \right) + (-1) 20 \right]$$

$$a_{10} = 1677$$

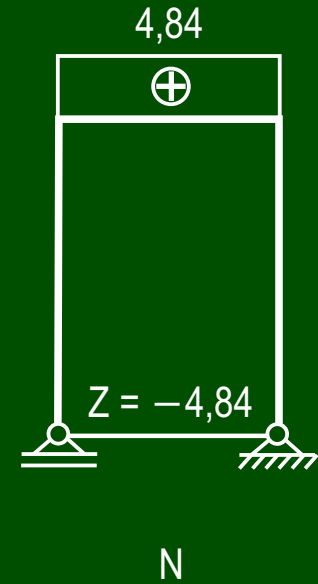
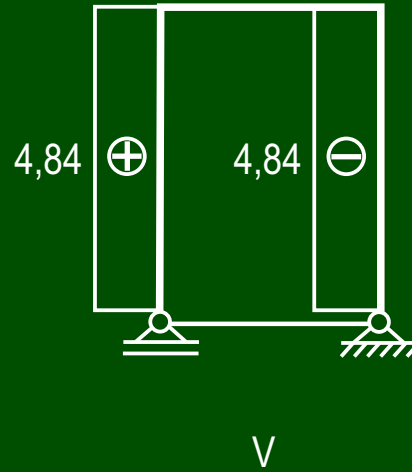
Vorzahl

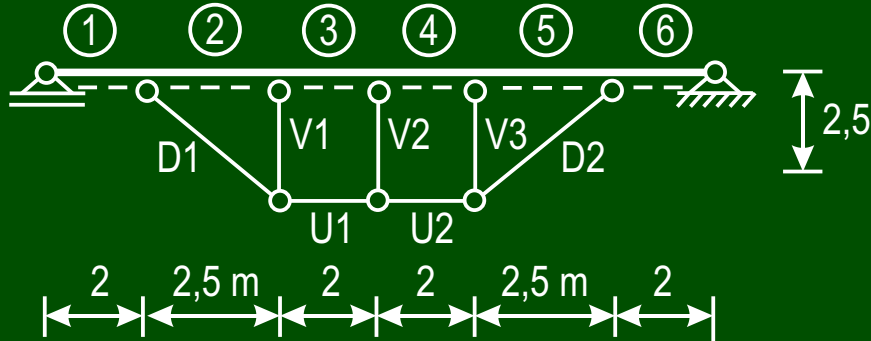
$$a_{11} = 8 \frac{1}{3} (-6)^2 + 8 \frac{1}{3} (-6)^2 + 4 (-6)^2 + 10,24 \cdot 1^2 = 346,2$$

aus N im Zugband

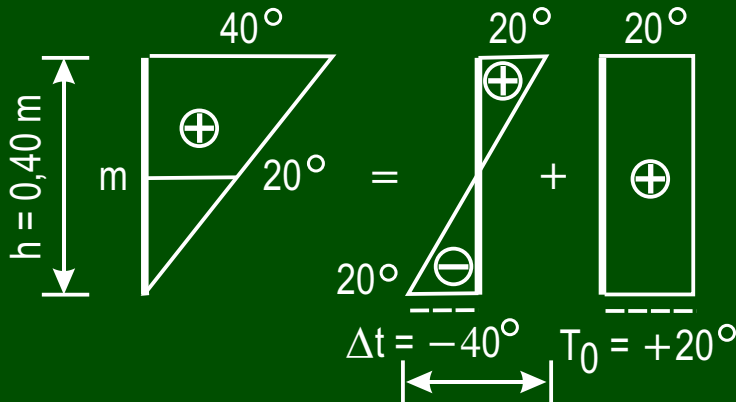
Gleichung

$$a_{11} X_1 = -a_{10} \quad \text{daraus} \quad X_1 = -4,84$$





Temperaturänderung in den
biegesteifen Stäben 1 – 6



Biegesteife Stäbe 1 – 6

$$J_1 \dots J_6 = 29\,000 \text{ cm}^4$$

$$E_1 \dots E_6 = 2.1 \cdot 10^8 \text{ kN/m}^2$$

Höhe der Stäbe : $h = 40 \text{ cm}$

Fachwerkstäbe

$$A = 25 \text{ cm}^2$$

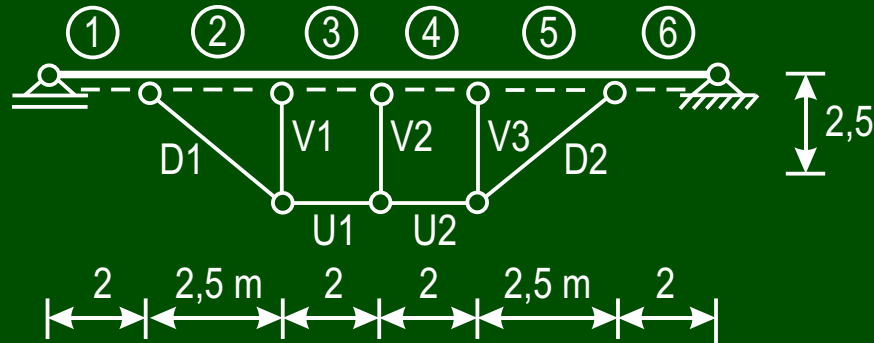
$$E = 2.1 \cdot 10^8 \text{ kN/m}^2$$

Temperaturänderung in den
biegesteifen Stäben 1 – 6

Erwärmung außen um $+40^\circ \text{ C}$

$$\alpha_t = 1.2 \cdot 10^{-5} \text{ Grad}^{-1}$$

Gewählt: $J_0 = J_1$; $E_0 = E_1$



$$E_0 J_0 \alpha_t = 0,731 \text{ kN} \cdot \text{m}^2 \cdot \text{Grad}^{-1}$$

Reduzierte Stablängen

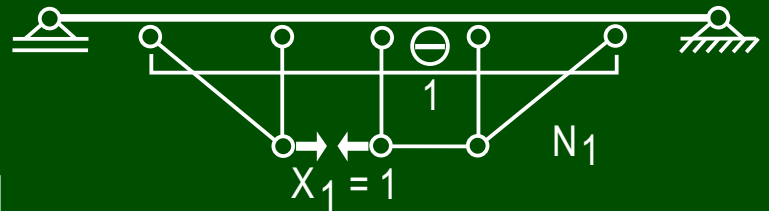
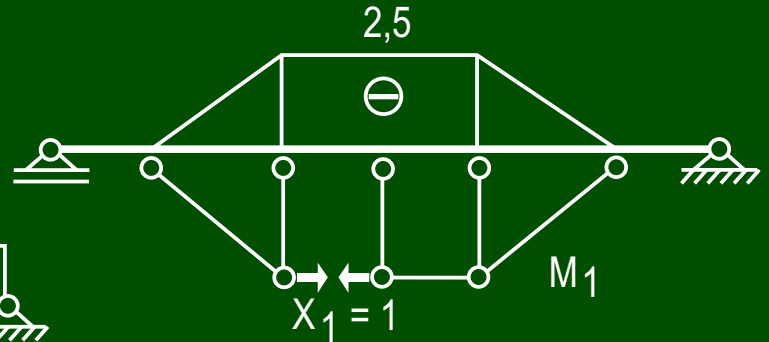
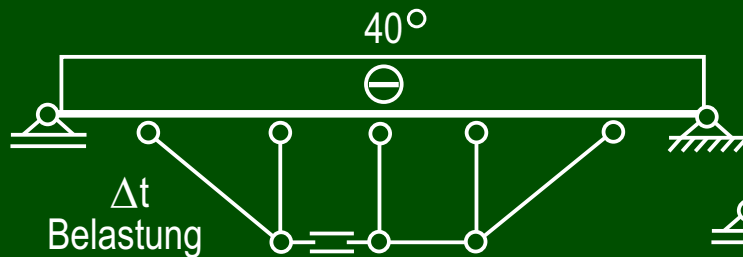
$$L'_1 = L'_3 = L'_4 = L'_6 = 2 \text{ m} \quad ; \quad L'_2 = L'_5 = 2,5 \text{ m}$$

$$L^{(4)}_1 = L^{(4)}_3 = L^{(4)}_4 = L^{(4)}_6 = 1,462 \text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1} \quad ; \quad L^{(4)}_2 = L^{(4)}_5 = 1,828 \text{ kN} \cdot \text{m}^3 \cdot \text{Grad}^{-1}$$

$$U1, U2 \quad : \quad L'' = 0,232 \text{ m}^3$$

$$V1, V2, V3 \quad : \quad L'' = 0,290 \text{ m}^3$$

$$D1, D2 \quad : \quad L'' = 0,411 \text{ m}^3$$



Stab	1	2	3
U	1	1	
V	-1	0	-1
D	1,414	1,414	

N_1

$$a = E_0 J_0 1^* \delta$$

Belastungszahl

aus Δt

aus T_0

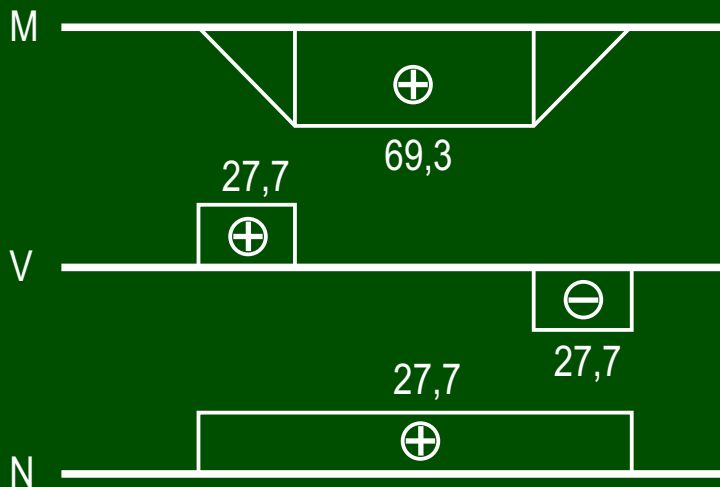
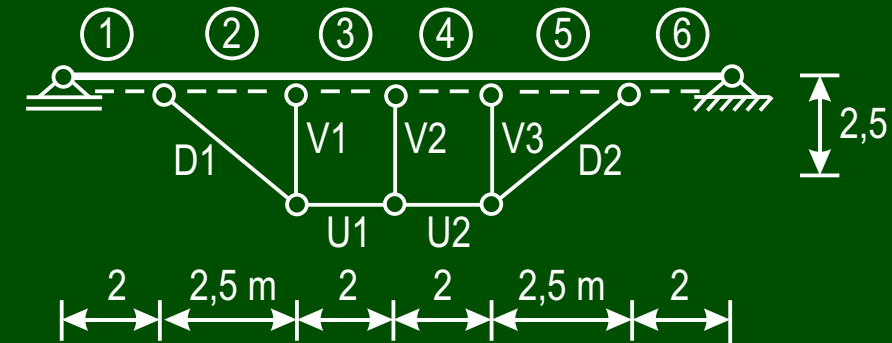
$$a_{10} = 2 \cdot 1,828 \left[\frac{1}{2} (-2,5) \left(\frac{-40}{0,4} \right) + (-1) 20 \right] \\ + 2 \cdot 1,462 \left[1 (-2,5) \left(\frac{-40}{0,4} \right) + (-1) 20 \right] = 1056,4$$

Vorzahl

$$a_{11} = 2 \cdot 2,5 \frac{1}{3} (-2,5)^2 + 2 \cdot 2 (-2,5)^2 + \\ + 2 \cdot 0,232 \cdot 1^2 + 2 \cdot 0,290 (-1)^2 + 2 \cdot 0,411 \cdot 1,414^2 = 38,1$$

Gleichung

$$a_{11} X_1 = -a_{10} \text{ daraus } X_1 = -27,7$$



Stab	1	2	3
U	-27,7	-27,7	
V	27,7	0	27,7
D	-39,2	-39,2	