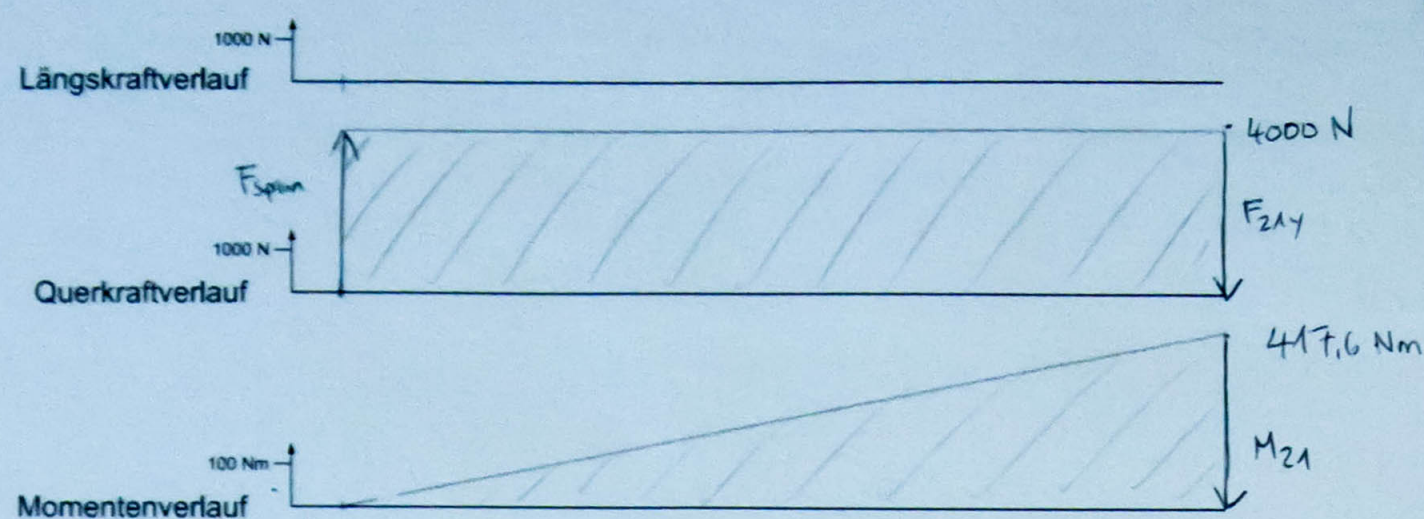
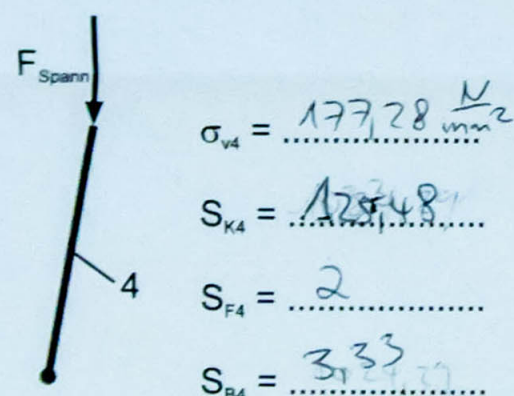
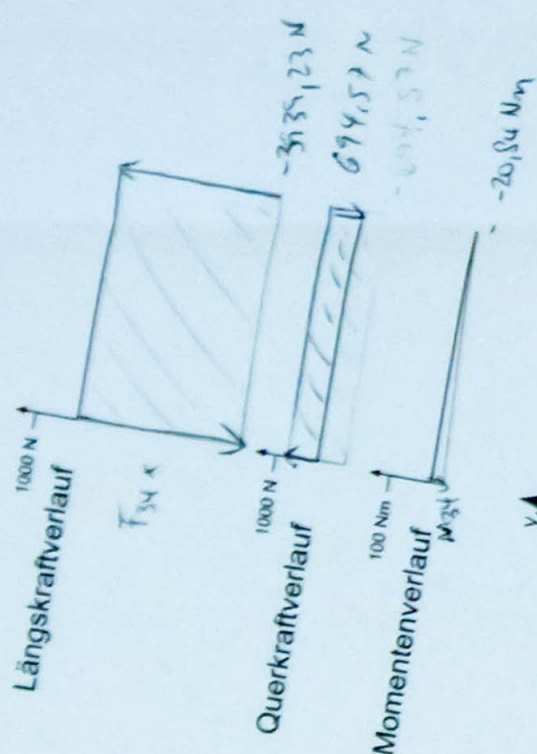
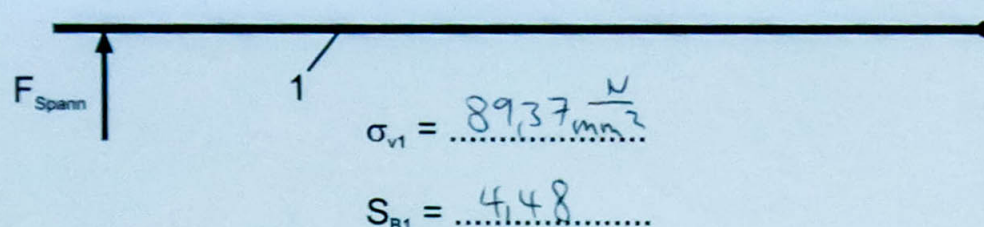


Konstruktionsübung 1 (KÜ 1): Berechnung einer Schraubzwinge

Freigeschnittene Schraubzwinge, M 1:1 (DIN-A3)


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 Technisches Design
 17. JAN. 2014


$$\sigma_{v2} = 310.5 \frac{\text{N}}{\text{mm}^2}$$

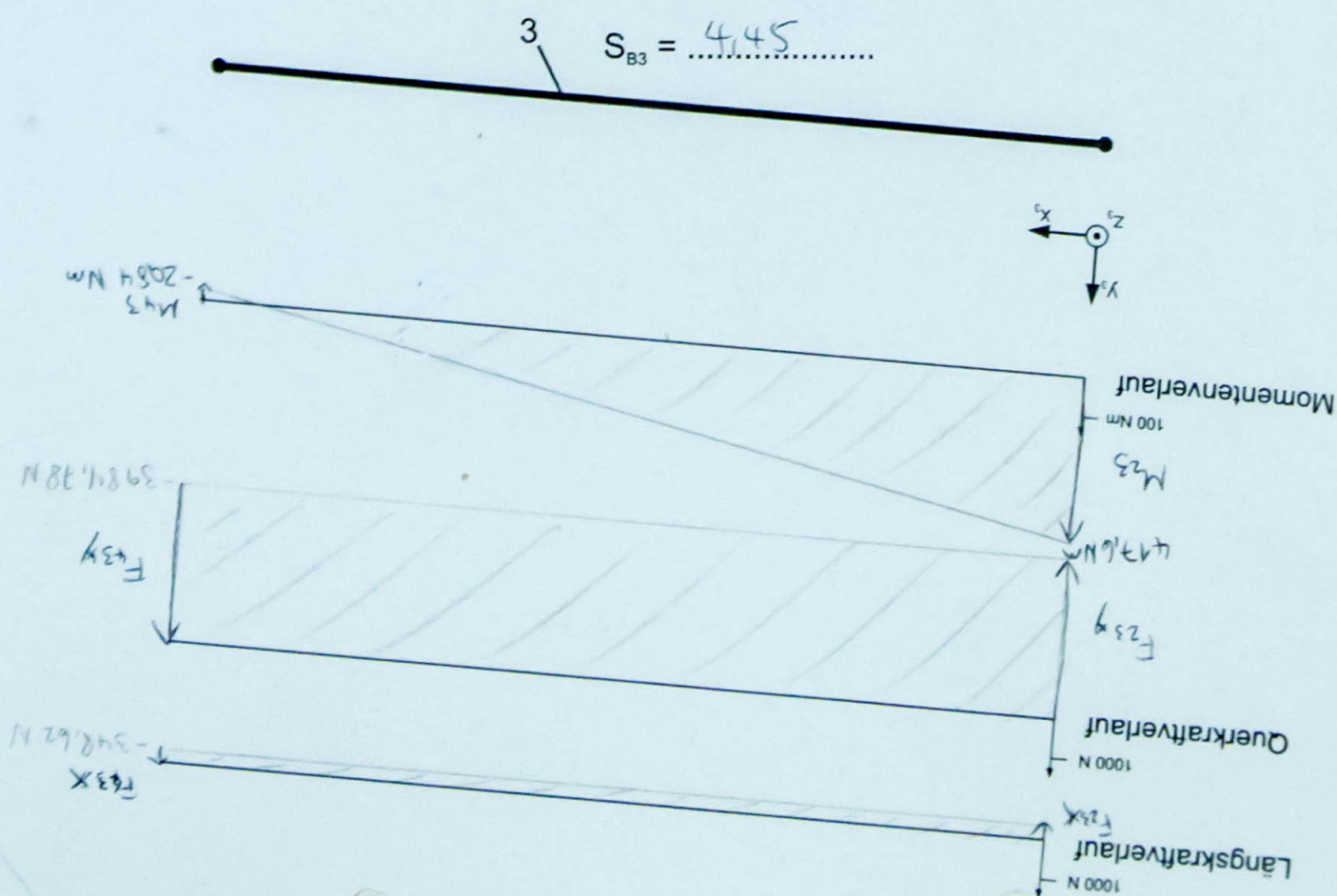
$$S_{F2} = 1.08$$

$$S_{B2} = 1.84$$

$$\sigma_{v3} = 89.92 \frac{\text{N}}{\text{mm}^2}$$

$$S_{K3} = 837.51$$

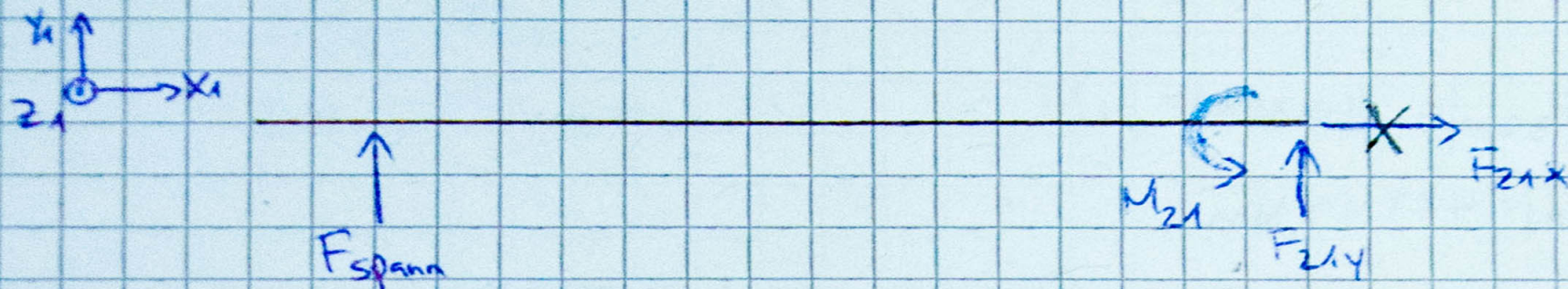
$$S_{B3} = 4.45$$



Konstruktionsübung 1: Berechnung einer Schraubzwinge

1. Freischneiden & Reaktionskräfte

BT1

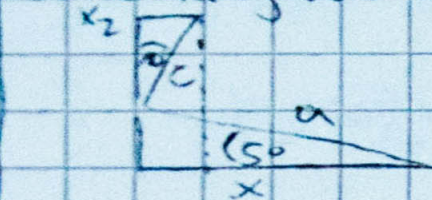


$$\sum F_x: F_{21x} = 0$$

$$\sum F_y: F_{\text{spann}} + F_{21y} = 0 \Rightarrow F_{21y} = -F_{\text{spann}} = -4000 \text{ N}$$

$$\sum M_z: M_{21} - F_{\text{spann}} \cdot a' = 0 \Rightarrow M_{21} = F_{\text{spann}} \cdot a' = 417,6 \text{ Nm}$$

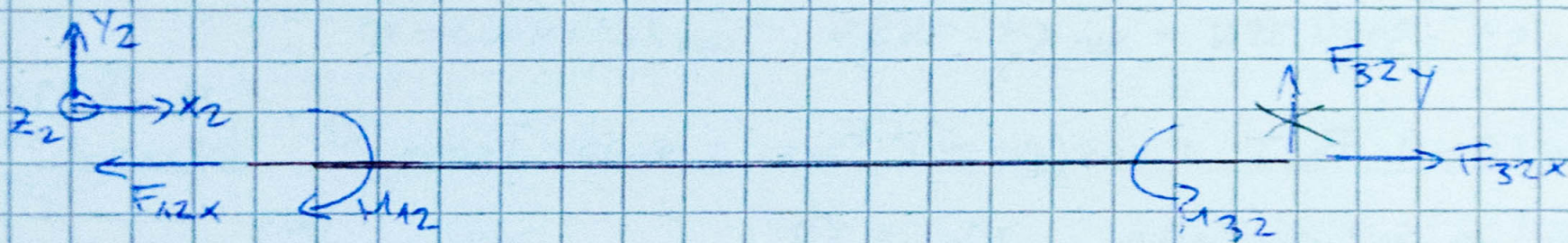
Berechnung von a' :



$$\cos 50^\circ = \frac{x}{c} \rightarrow x = 109,6 \text{ mm} \quad \sin 10^\circ = \frac{x_2}{c} \rightarrow x_2 = 5,2 \text{ mm}$$

$$a' = x - x_2 = 104,4 \text{ mm}$$

BT2



$$|F_{12x}| = |F_{21y}| = 4000 \text{ N}$$

$$|M_{12}| = |M_{21}| = 417,6 \text{ Nm}$$

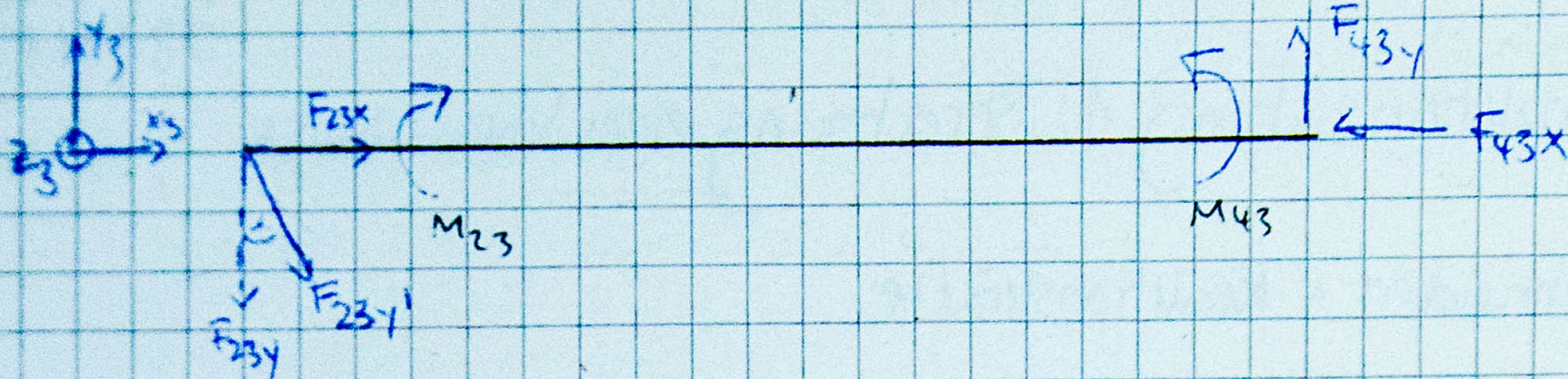
$$\sum F_x = 0: -F_{12x} + F_{32x} = 0 \Rightarrow F_{32x} = -F_{12x} = +4000 \text{ N}$$

$$\sum F_y = 0: F_{32y} = 0$$

$$\sum M_z = 0: -M_{12} + M_{32} = 0 \Rightarrow M_{32} = -417,6 \text{ Nm}$$

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BT3



$$F_{23y}' = -F_{32x} = 4000 \text{ N}$$

$$M_{23} = -M_{32} = 417,49 \text{ Nm}$$

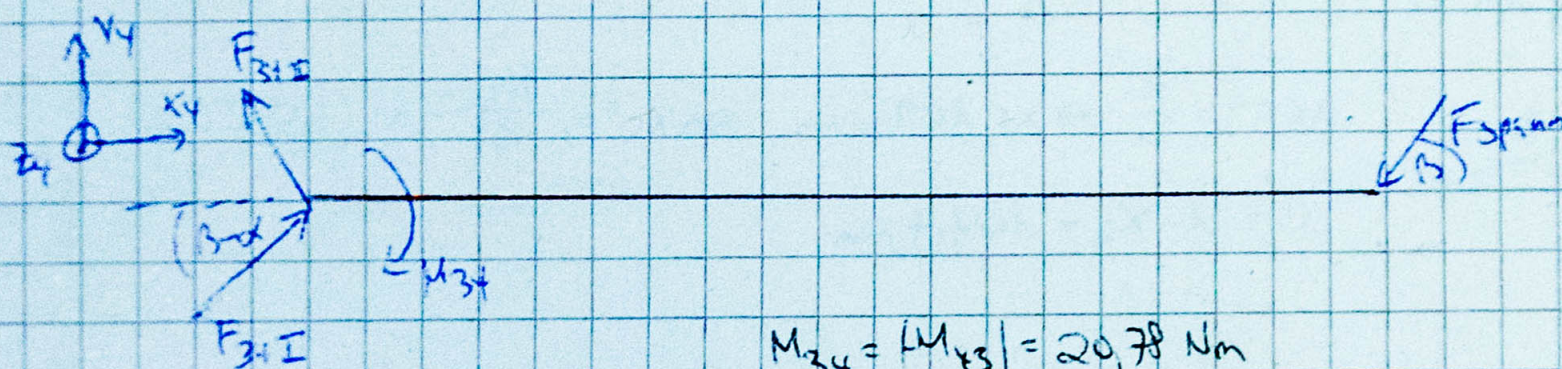
$$\sum F_x = 0: \sin \alpha \cdot F_{23y}' - F_{43x} = 0 \rightarrow F_{43x} = 348,62 \text{ N}$$

$$\sum F_y = 0: -\cos \alpha \cdot F_{23y}' - F_{43y} = 0 \rightarrow F_{43y} = +3984,78 \text{ N}$$

$$\sum M = 0: -M_{23} + M_{43} + a \cdot 3984,78 \text{ N} = 0 \rightarrow M_{43} = -20,78 \text{ Nm}$$

$$|M_{43}| = 20,78 \text{ Nm}$$

BT4



$$M_{34} = |M_{43}| = 20,78 \text{ Nm}$$

$$\sum F_x = 0: \cos 5^\circ \cdot 3984,78 \text{ N} - \sin 5^\circ \cdot 348,6 - \cos 10^\circ \cdot 4000 = 0$$

$$\sum F_y = 0: \sin(\beta - \alpha) \cdot F_{34I} + \cos(\beta - \alpha) \cdot F_{34II} + \sin \beta \cdot F_{spinn} = 0$$

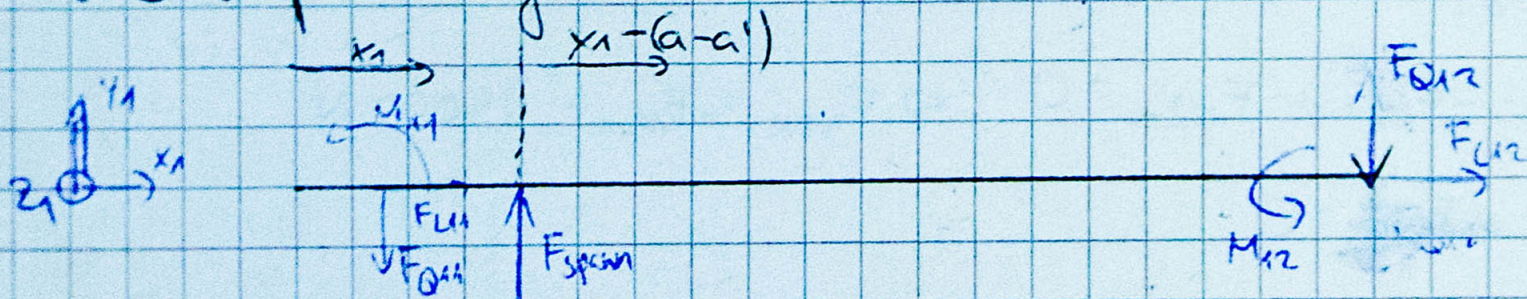
$$F_{34I} = 3984,78 \text{ N}$$

$$F_{34II} = 348,6 \text{ N}$$

$$\sum M = 0: -c \cdot \sin 10^\circ \cdot 4000 \text{ N} + M_{34} = 0$$

2. Beanspruchungen

BT1



$$\sum F_x: F_{11} = 0$$

$$\sum F_y: F_{12} = 0$$

$$\sum M_z: M_{11} = 0$$

$$\sum F_x: F_{12} = 0$$

$$\sum F_y: F_{11} + F_{spinn} = 0$$

$$\sum M: M_{12} - F_{spinn} (x_1 - (a - a')) = 0$$

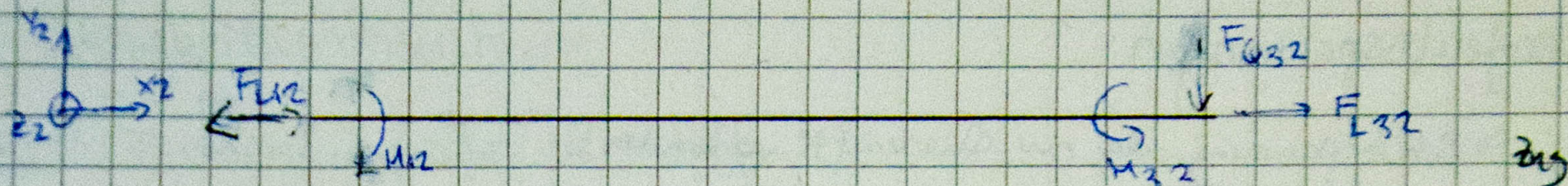
$$\Rightarrow F_{11} = -F_{spinn}$$

$$M_{12} = F_{spinn} (x_1 - a + a') = F_{spinn} \cdot x - F_{spinn} (a - a')$$

$$\text{linker Rand: } x_1 = a - a' \rightarrow M_{12} = 0 \text{ Nm}$$

$$\text{rechter Rand: } x_1 = a \Rightarrow |M_{12}| = 417,6 \text{ Nm}$$

B72

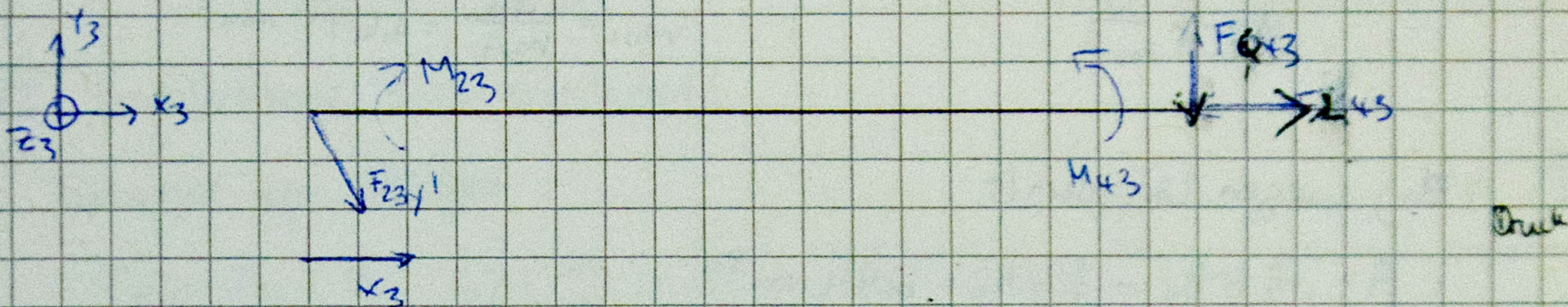


$$\sum F_x = -F_{L21} + F_{L32} = 0 \Rightarrow F_{L21} = F_{L32}$$

$$\sum F_y = F_{Q21} = 0$$

$$\sum M = -M_{12} + M_{32} = 0 \Rightarrow M_{12} = M_{32}$$

B73



$$\sum F_x = \sin \alpha \cdot F_{23y'} + F_{Q32} \Rightarrow F_{L43} = -348,62 \text{ N}$$

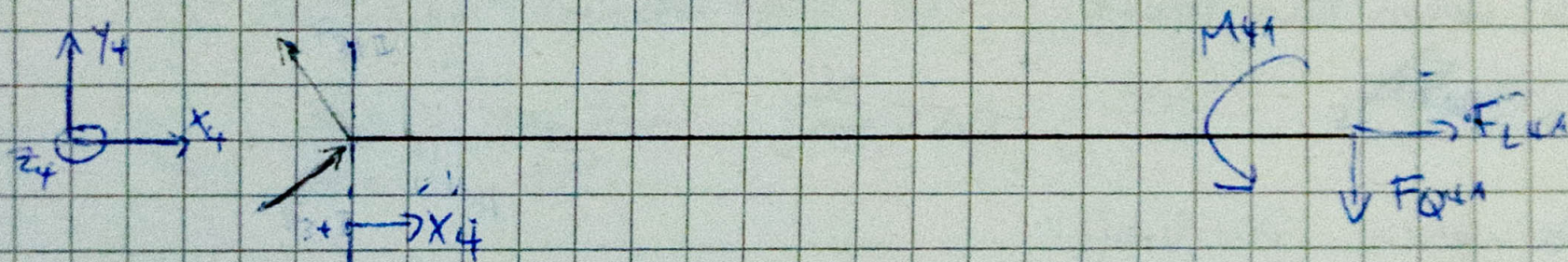
$$\sum F_y = -\cos \alpha \cdot F_{23y'} - F_{L32} = 0 \Rightarrow F_{L32} = -3984,78 \text{ N}$$

$$\sum M = 0: -M_{23} + M_{43} + x_3 \cdot F_{L32} = 0 \Rightarrow M_{43} = 417,6 \text{ Nm} - x_3 \cdot 3984,78 \text{ N}$$

$$\text{linker Rand: } x_3 = 0 \Rightarrow M_{43} = 417,6 \text{ Nm}$$

$$\text{rechter Rand: } x_3 = a = 9 \text{ m} \Rightarrow M_{43} = -20,84 \text{ Nm}$$

B74



$$\sum F_x = \cos 5^\circ \cdot 3984,78 \text{ N} - \sin 5^\circ \cdot 348,6 \text{ N} - \cos 10^\circ \cdot 400 \text{ N} = 0$$

$$= F_{L41} = 3939,23 \text{ N}$$

$$\sum F_y = \sin(\beta - \alpha) \cdot 3984,78 \text{ N} + \cos(\beta - \alpha) \cdot 348,6 \text{ N} + \sin \beta \cdot F_{Q41} = 0$$

$$= F_{Q41} = 694,57 \text{ N}$$

$$\sum M = 0: M_{43} + F_y \cdot x_4 = 0$$

$$\text{links: } x_4 = 0 \Rightarrow M_{41} = -20,84 \text{ Nm}$$

$$\text{rechts: } x_4 = l \Rightarrow M_{41} = 0 \text{ Nm}$$

3 Vergleichsspannungen

BT1 → Schubspannung, da nur Querkräfte vorhanden:

$$\tau(x) = \frac{F_Q}{A} = \frac{4000}{630} = 6,35 \frac{\text{N}}{\text{mm}^2}$$

→ Biegung aus Biegemoment

$$\sigma_{b1} = \frac{-M_{12}}{W_{b1}}$$

$$= 89,3 \frac{\text{N}}{\text{mm}^2}$$

Flächenträgheitsmoment:

$$I_1 = 4b \frac{h_2^3}{12} - 2b \frac{h_1^3}{12} = 81812,5 \text{ mm}^4$$

Widerstandsmoment

$$W_{b1} = \frac{I_1}{h_2/2} = 4675 \text{ mm}^3$$

BT2 → Zug wegen Längskraft

$$A = \frac{3}{2}b h_4 - \frac{1}{2}b h_3 = 244 \text{ mm}^2$$

$$\sigma = \frac{F_{L2}}{A} = \frac{4000 \text{ N}}{A} = 16,33 \frac{\text{N}}{\text{mm}^2}$$

→ Biegung aus Biegemoment

$$\sigma_{b2} = \frac{M_{21}}{W_{b2}}$$

$$= 294,2 \frac{\text{N}}{\text{mm}^2}$$

$$I_2 = \frac{3}{2}b \frac{h_4^3}{12} - \frac{1}{2}b \frac{h_3^3}{12} = 21291,67 \text{ mm}^4$$

$$W_{b2} = \frac{I_2}{h_4/2} = 1419,44 \text{ mm}^3$$

BT3 → Druck wegen Längskraft

$$A = 630 \text{ mm}^2$$

$$\sigma_{d3} = \frac{F_{L3}}{A} = \frac{348,62}{A} = -0,55 \frac{\text{N}}{\text{mm}^2}$$

→ Schub wegen Querkraft:

$$\tau(x) = \frac{F_{Q3}}{A} = \frac{-3784,78 \text{ N}}{630 \text{ mm}^2} = -6,33 \frac{\text{N}}{\text{mm}^2}$$

→ Biegung:

$$\sigma_{b3} = \frac{M_b}{W_b}$$

$$= 89,3 \frac{\text{N}}{\text{mm}^2} = \sigma_{b1}$$

$$I_3 = I_1 = 81812,5 \text{ mm}^4$$

$$W_{b3} = W_{b1} = 4675 \text{ mm}^3$$

BT4 → Druck wegen Längskraft

$$\sigma_{d4} = \frac{F_{L4}}{A} = -37,93 \frac{\text{N}}{\text{mm}^2}$$

→ Schub wegen Querkraft:

$$\tau(x) = \frac{F_{Q4}}{A} = 6,69 \frac{\text{N}}{\text{mm}^2}$$

→ Biegung:

$$\sigma_{b4} = \frac{M_{b4}}{W_b} = -139,56 \frac{\text{N}}{\text{mm}^2}$$

$$W_b = \frac{I_1}{32} d^3 = 149,21 \text{ mm}^3$$

4. Festigkeitsuntersuchung

(B1) Festarm, spröder Werkstoff

Sicherheit gegen Bruch: FB $\sigma_{v1} \leq \sigma_{zul}$

$$\sigma_{v1} = \sqrt{\frac{1}{2} (\sigma_b^2 + 3\tau^2)} = 90,52 \frac{N}{mm^2}$$

$$S_{B1} = \frac{R_{m1}}{\sigma_{v1}} = \frac{400 \frac{N}{mm^2}}{90,52} = 4,48 \in [4; 9]$$

(B2) Profilschiene, zäher Werkstoff

Sicherheit gegen Fließen:

$$\sigma_{v2} = \sigma_{z2} + \sigma_{bz2} = 16,33 \frac{N}{mm^2} + 294,2 \frac{N}{mm^2} = 310,5 \frac{N}{mm^2}$$

$$S_{F1} = \frac{R_e}{\sigma_{v2}} = \frac{335 \frac{N}{mm^2}}{310,5} = 1,08 \notin [1,2; 2] \quad \downarrow$$

Sicherheit gegen Bruch:

$$S_{B1} = \frac{R_m}{\sigma_{v2}} = \frac{570 \frac{N}{mm^2}}{310,5} = 1,84 \notin [2; 3] \quad \downarrow$$

→ Man könnte einen überwertigen Stahl nehmen

(B3) Schiebearm, spröder Werkstoff

$$\sigma_{v3} = \sqrt{\frac{1}{2} (\sigma_b^2 + 3\tau^2)} = 90,52 \frac{N}{mm^2}$$

$$S_{B3} = \frac{R_{m3}}{\sigma_{v3}} = \frac{400 \frac{N}{mm^2}}{90,52} = 4,45 \in [4; 9]$$

→ Eulersche Knicklast - Fall 1:

$$F_{K3} = \frac{\pi^2}{4} \cdot \frac{E_3 \cdot I_3}{l^2} = \frac{\pi^2}{4} \cdot \frac{175000 \frac{N}{mm^2} \cdot 81812,5 mm^4}{(110 mm)^2} = 2919524,31 N$$

$$S_{K3} = \frac{F_{K3}}{F_{32}} = \frac{2919524,31 N}{358,62 N} = 8174,51$$

(B4) Spindelleinheit, zäher Werkstoff

$$\sigma_{v4} = \sqrt{(\sigma_{b4} + \sigma_{bz4})^2 + 3\tau^2} = 177,28 \frac{N}{mm^2}$$

$$S_{F4} = \frac{R_{e4}}{\sigma_{v4}} = 2 \in [1,2-2]$$

$$S_{B4} = \frac{R_{m4}}{\sigma_{v4}} = 3,33 \notin [2; 3]$$

$$F_K = \frac{\pi}{64} \cdot (11,5 mm)^4$$

→ Eulersche Knicklast - Fall 1:

$$F_{K4} = \frac{\pi^2}{4} \cdot \frac{E_4 \cdot I_4}{l^2} = \frac{\pi^2}{4} \cdot \frac{210000 \frac{N}{mm^2} \cdot 858,5 mm^4}{(30 mm)^2} = 494285,41 N$$

$$S_{K4} = \frac{F_{K4}}{F_{41}} = 125,48$$

Fazit: Bei Bauteile 1, 3 & 4 reicht die Festigkeit aus, jedoch kann die Profilschiene versagen.