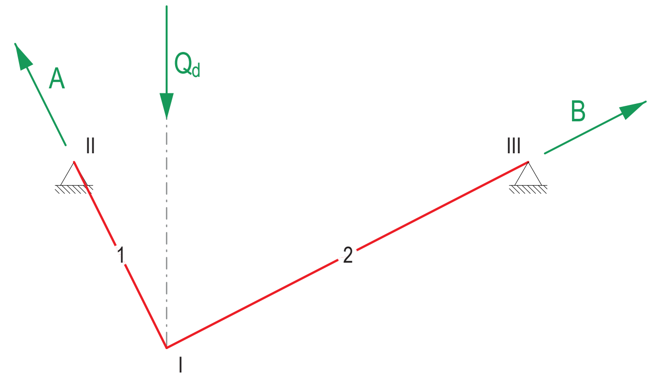
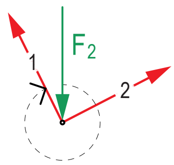
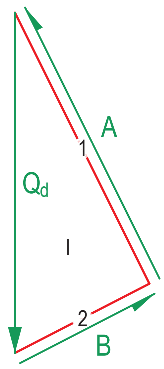
Given is the form diagram of a cable made out of steel S235 under the live point load Q_k = 30 kN. The required diameter of this cable is to be found.
First the characteristic value ($_k$) of the acting force Q must be brought to the design level ($_d$). This is achieved by multiplying with the safety factor. Since the magnitude of a load over the lifetime of a structure cannot always be exactly predicted, a safety factor γ is calculated for each load. For dead loads the safety factor is γ_G=1.35 and for live loads γ_Q=1.5. With the found force Q_d the force diagram can be drawn.



$Q_d = Q_k \cdot \gamma_Q$
$= 30\text{ kN} \cdot 1.5$
$= \underline{45\text{ kN}}$





To calculate the cable diameter, the relevant force N_{dmax} in the structure is determined. The relevant force is understood to be the largest internal force. In this case, this is element 1 with a length of 4 cm, and therefore a magnitude of 40 kN.

N_1 = 40 kN = $\mathbf{N_{dmax}}$
N_2 = 20 kN
A = 40 kN
B = 20 kN

If the relevant force N_{dmax} is divided by the material strength f_d, the required cross-sectional area A_{req} is obtained.

$\mathbf{A_{req} = N_d / f_{td}}$

The strength of the given material can be taken from the formulary. Since 1 is a tensile element, the allowable tensile stress f_{tk} is relevant. A material safety factor γ_M is also included in the values of the material's strength to consider errors in the material. In contrast to the safety factor of the load, however, f_{tk} is divided by γ_M. γ_M is material-specific and can therefore also be taken from the formulary.

$f_{td} = f_{tk} / \gamma_M$
$= 235\text{ N/mm}^2 / 1.05 = 223.81\text{ N/mm}^2$

$A_{req} = N_d / f_{td}$
$= 40\text{ kN} / 223.81\text{ N/mm}^2 = 178.7\text{ mm}^2$

Finally, the diameter is found using the formula for the circular area. Important: The result is always rounded up, as rounding off would result in a diameter smaller than the minimum requirement.

$A = r^2 \cdot \pi = (D/2)^2 \cdot \pi$
$D = 2 \cdot \sqrt{A/\pi}$
$= 2 \cdot \sqrt{178.7\text{ mm}^2 / \pi} = 15.08\text{ mm} \approx \underline{16\text{ mm}}$

Stress proof

A cable cross-section of steel S355 with a diameter D=20mm under a relevant tensile force N_d = 80kN is given. The proof is sought whether the cross-section of the cable can withstand the given load.

$\mathbf{N_d \leq N_{allow} = f_{td} \cdot A_{ef}}$

First, the maximum allowed force N_{allow} of the cable is to be found. This is calculated by multiplying the designed allowable tensile stress f_{td} with the effective cross-sectional area A_{ef} based on the given diameter of the cable.

$A_{ef} = r^2 \cdot \pi = (D/2)^2 \cdot \pi$
$= (20\text{ mm}/2)^2 \cdot \pi = 314.16\text{ mm}^2$

Second, the found force N_{allow} is then compared with the relevant force N_d. If N_{allow} is equal to or larger than N_d, the proof is provided and the given cross-section withstands the applied load. If the proof is not fulfilled, the cable must be re-dimensioned.

$N_{allow} = f_{td} \cdot A_{ef}$
$N_{allow} = 338.1\text{ N/mm2} \cdot 314.16\text{ mm}^2 = \underline{106.2\text{ kN}}$

$N_d = 80\text{ kN}$ $\quad$ $\mathbf{N_d \leq N_{allow}}$ ✓