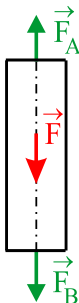


Analysis:

straight bar, supported, loaded by forces and deformations (the bar is produced with a **small** inaccuracy, it is the value of δ shorter than the distance between the plates of the base, to which it should be welded by both of its ends; after the assemblage, the bar is thus loaded also by deformation).

Free body diagram:


Resultants consisting of three force and three moment components can be created in each of the (fixed in 3D space) supports A and B. If we ensure a sufficient coaxiality and alignment of the supports, the components without any significant external loads in their direction will be negligible, and the only one significant component of the support resultant will be the force parallel to the bar centreline and thus also to the external loads.

Statical analysis:

$\mu = 2, \quad \nu = 1$ (a system of forces acting in the same line)

$s = \mu - \nu = 1 \Rightarrow$ statically onefold indeterminate system

Applicable conditions of static equilibrium: $F_x : F_A - F - F_B = 0$

Released structure:

Back to
problem

supported
bar

deformation
loading

supports

statical
analysis

conditions
nonhomogeneous

released
structure

Distribution of the inner resultant:

$$x \in (0, b) : N_I = F_B$$

$$x \in (0, a) : N_{II} = F + F_B$$

Modification of the compatibility equations:

$$u_B = \frac{F_B}{ES}b + \frac{F + F_B}{ES}a = \delta$$

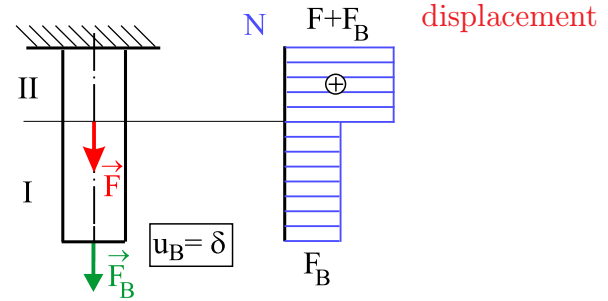
Set of equations:

$$F_A - F - F_B = 0$$

$$\frac{F_B}{ES}b + \frac{F + F_B}{ES}a = \delta$$

Solution:

$$F_B = \frac{\delta ES - Fa}{a + b}, \quad F_A = F + F_B = \frac{Fb + \delta ES}{a + b}.$$



Discussion:

If a state can occur in operation of a statically indeterminate supported body (e.g. in relation to the assemblage of the bars), in which the bar is loaded only by deformation, this state should be checked as well (by substitution $F = 0$ into these relations). The stress state can be worse in some points of the bar under these conditions than when the force is acting.

a) state after assemblage:

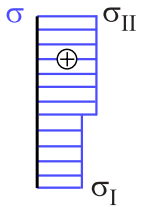
$$F = 0 \quad \Rightarrow \quad F_B = \frac{\delta ES}{a + b} \quad - \text{the whole bar is loaded in tension.}$$

b) state after assemblage and loaded by the force \vec{F} :

$$F_B = \frac{\delta ES - Fa}{a + b} \quad \Rightarrow \quad \text{Tension or compression can occur in the interval I in dependence on the values } \delta ES \text{ and } Fa.$$

Distribution of stresses:

stress



Since the bar is loaded in simple tension (compression), the stress is constant across the section and can be calculated using the following formula:

$$\sigma(x) = \frac{N(x)}{S(x)} : \quad \sigma_I = \frac{N_I}{S} = \frac{F_B}{S}, \quad \sigma_{II} = \frac{N_{II}}{S} = \frac{F_A}{S}$$

Check for the limit state of elasticity:

limit state

We determine the section with extreme stress (dangerous section) from the stress distribution and calculate the safety factor against the limit state of elasticity:

$$k_K = \frac{\sigma_K}{\sigma_{\max}}.$$

Note:

The stress states in supports A and B depend, in addition to the notch effect, on the technology of welding. Therefore we do not check them, although just these points can be dangerous. Similar, a stress concentration occurs in the point of action of the force \vec{F} , but this concentration is not specified in the example.