19. Nomograms for estimation of stress concentration factors

The formulas based on the simple elasticity theory of bars can be used if and only if the deviations from the bar assumptions are not substantial. As most of the real structures incorporate bodies with a sudden (stepwise) change in their cross sections, regions near such cross section changes must be judged from the viewpoint of the failure risk; most of the operation fractures occur just in these regions. The notch (i.e. stepwise change in the cross section) can be targeted (fillets, holes, shoulders etc.) or undesirable (cracks, inclusions).

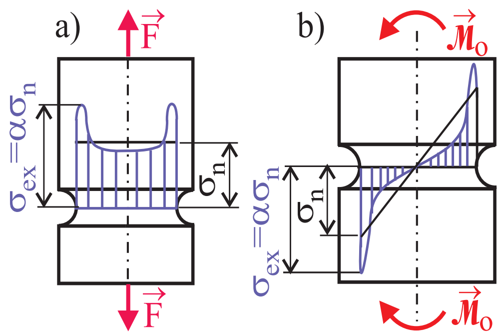
bar assumptions

limit state

notches

The presence of a notch causes a redistribution of stresses in the section, the notch causes a local strain concentration and, consequently, a stress concentration; in the notch surroundings the stress state does not meet the assumptions of the simple elasticity theory of bars and a **general triaxial stress state** occurs. The stress concentration can be quantified in the simplified way using the **stress concentration factor** α; this factor is defined by the following formulas

triaxial stress state



$$\alpha = \frac{\sigma_{ex}}{\sigma_n} \quad \text{(for loading in tension or flection)} \quad \text{and} \quad \alpha = \frac{\tau_{ex}}{\tau_n} \quad \text{(for loading in torsion).}$$

The nominal stresses σ_n and τ_n are stresses calculated using the formulas for simple tension, flection or torsion.

tension

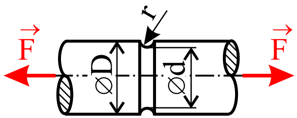
flection

torsion

The values of stress concentration factors α evaluated using numerical (FEM) or experimental (photoelasticimetry) methods are presented in the form of graphs (nomograms) for various notch shapes and various types of loads [7]. At any of these nomograms, the shape of the bar and of the notch is defined, and the formula used for calculation of nominal stress σ_n should be presented as well.

Circular bar with neck loaded in

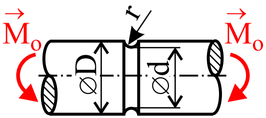
tension



$$\sigma_n = \frac{4F}{\pi d^2}$$

graph

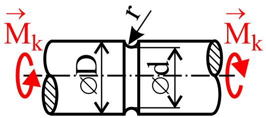
flection



$$\sigma_n = \frac{32M_o}{\pi d^3}$$

graph

torsion

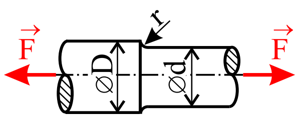


$$\tau_n = \frac{16M_k}{\pi d^3}$$

graph

Circular bar with shoulder loaded in

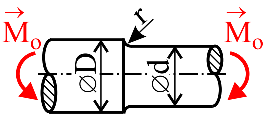
tension



$$\sigma_n = \frac{4F}{\pi d^2}$$

graph

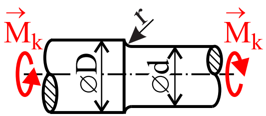
flection



$$\sigma_n = \frac{32M_o}{\pi d^3}$$

graph

torsion

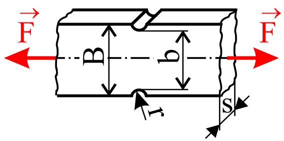


$$\tau_n = \frac{16M_k}{\pi d^3}$$

graph

Flat rectangular bar with neck loaded in

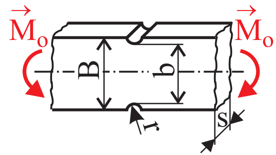
tension



$$\sigma_n = \frac{F}{bs}$$

graph

flection

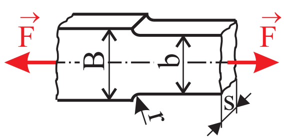


$$\sigma_n = \frac{6M_o}{b^2 s}$$

graph

Flat rectangular bar with shoulder loaded in

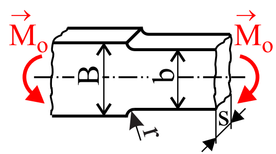
tension



$$\sigma_n = \frac{F}{bs}$$

graph

flection

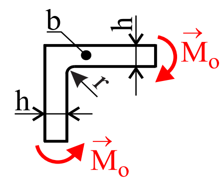


$$\sigma_n = \frac{6M_o}{b^2 s}$$

graph

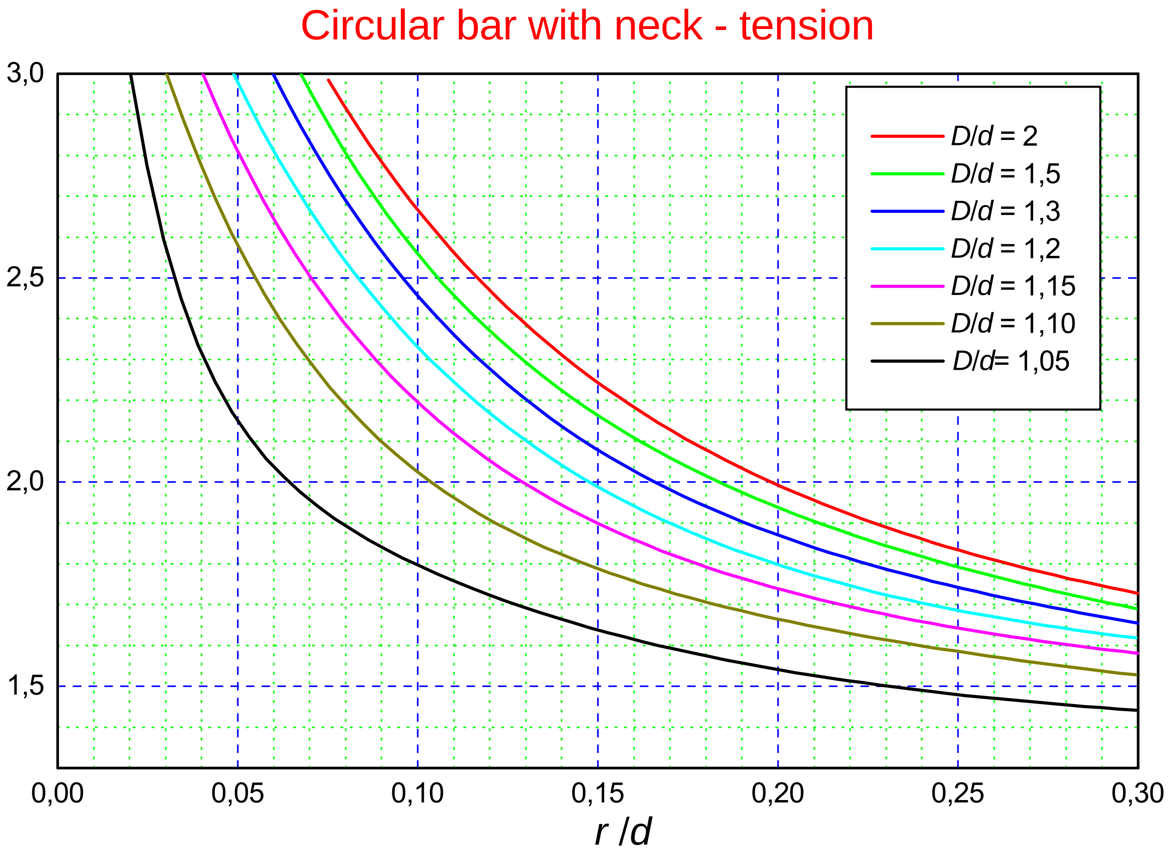
Angular beam loaded in

flection



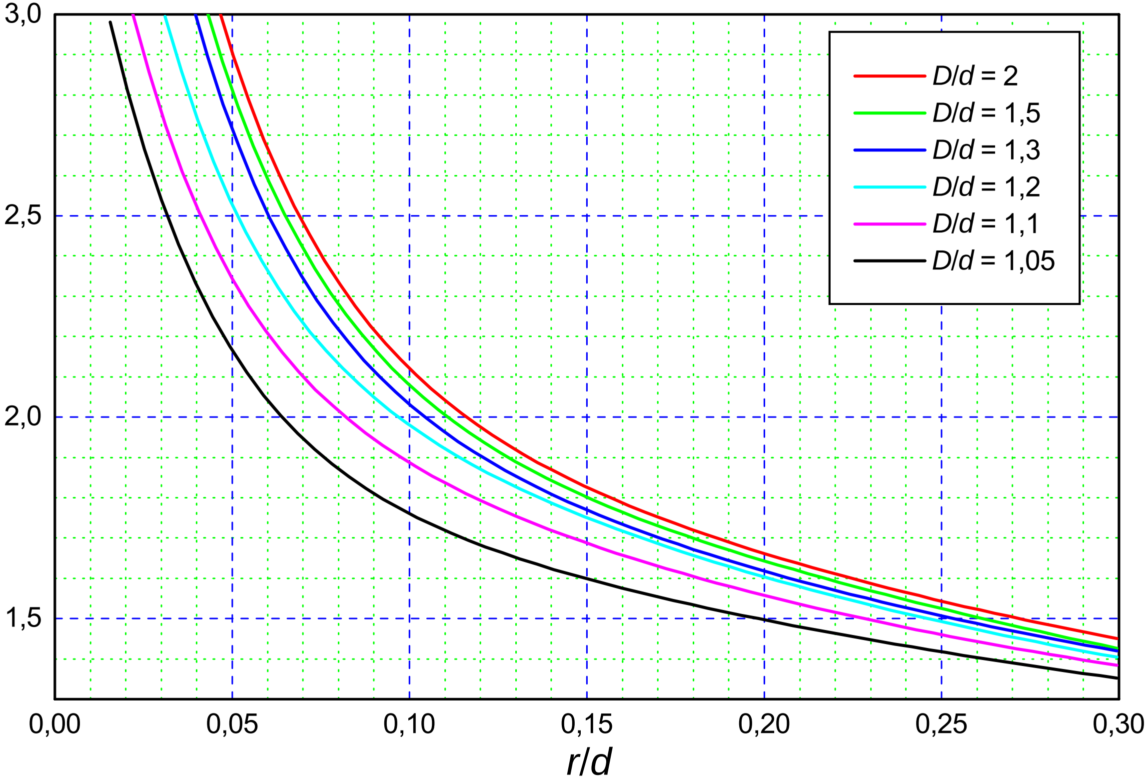
$$\sigma_n = \frac{6M_o}{bh^2}$$

graph

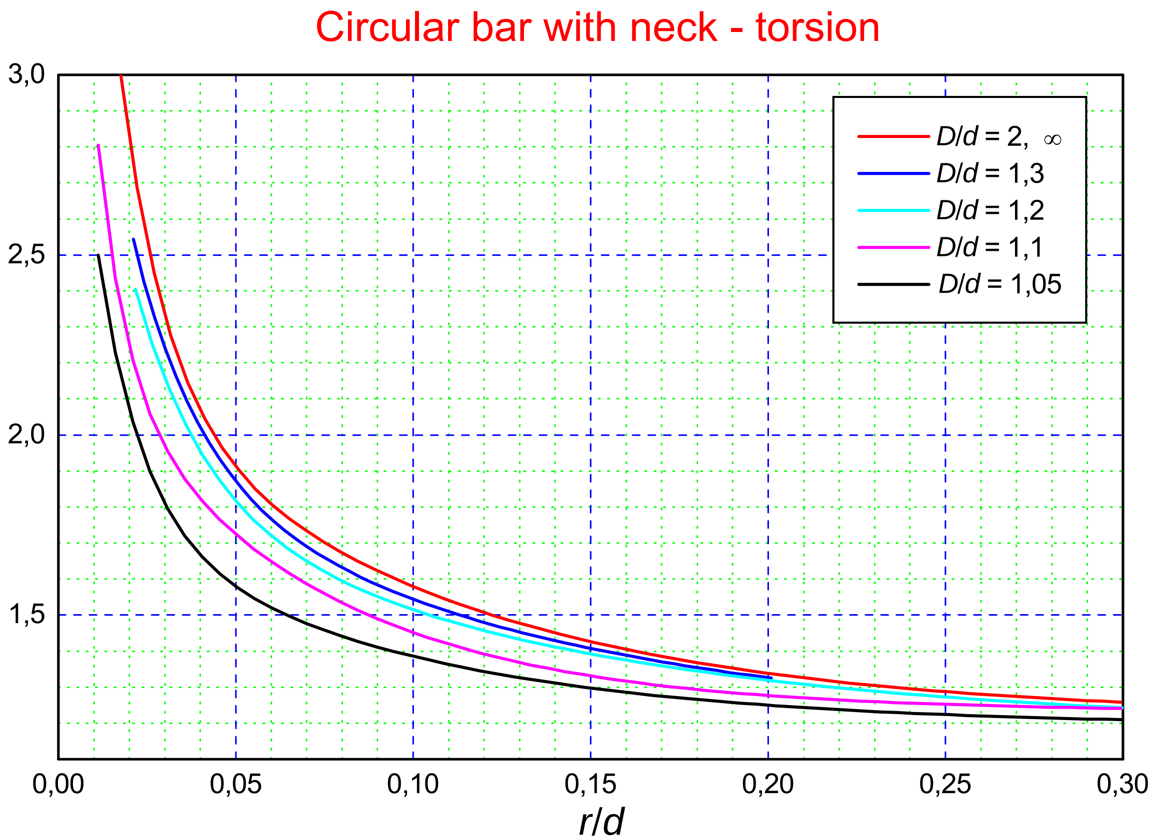


Overview of shapes

Circular bar with neck - flexion

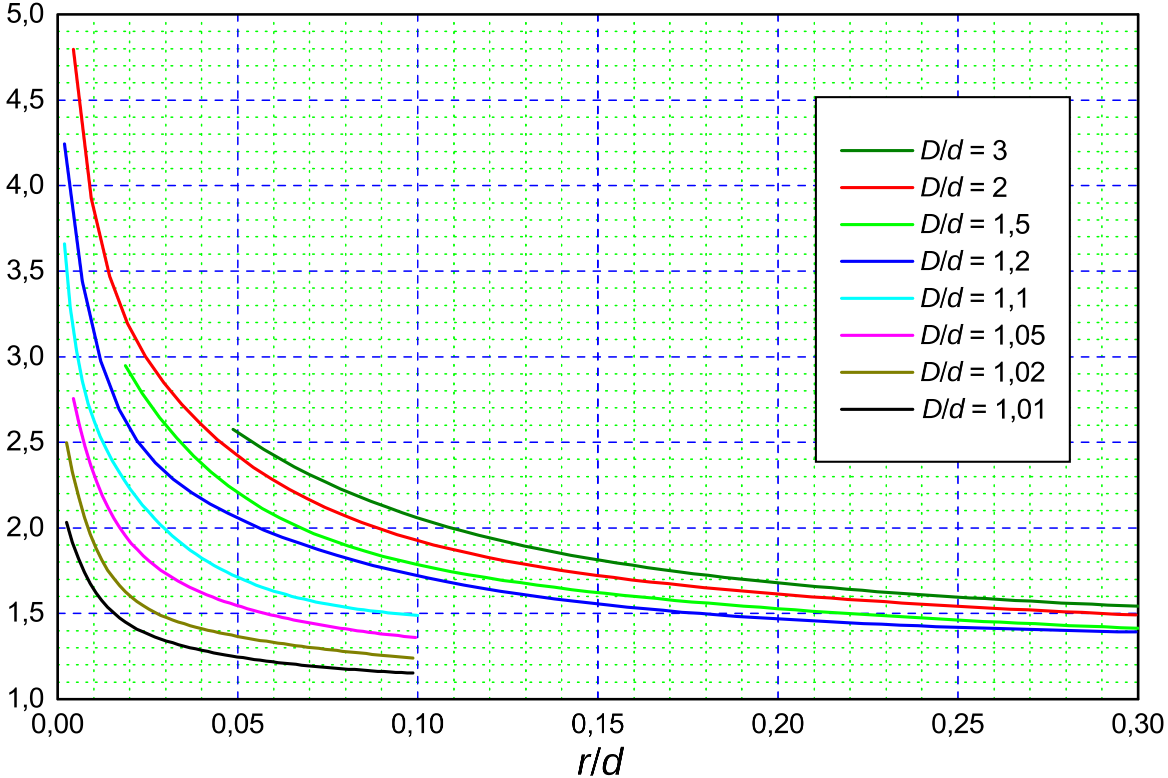


Overview of shapes

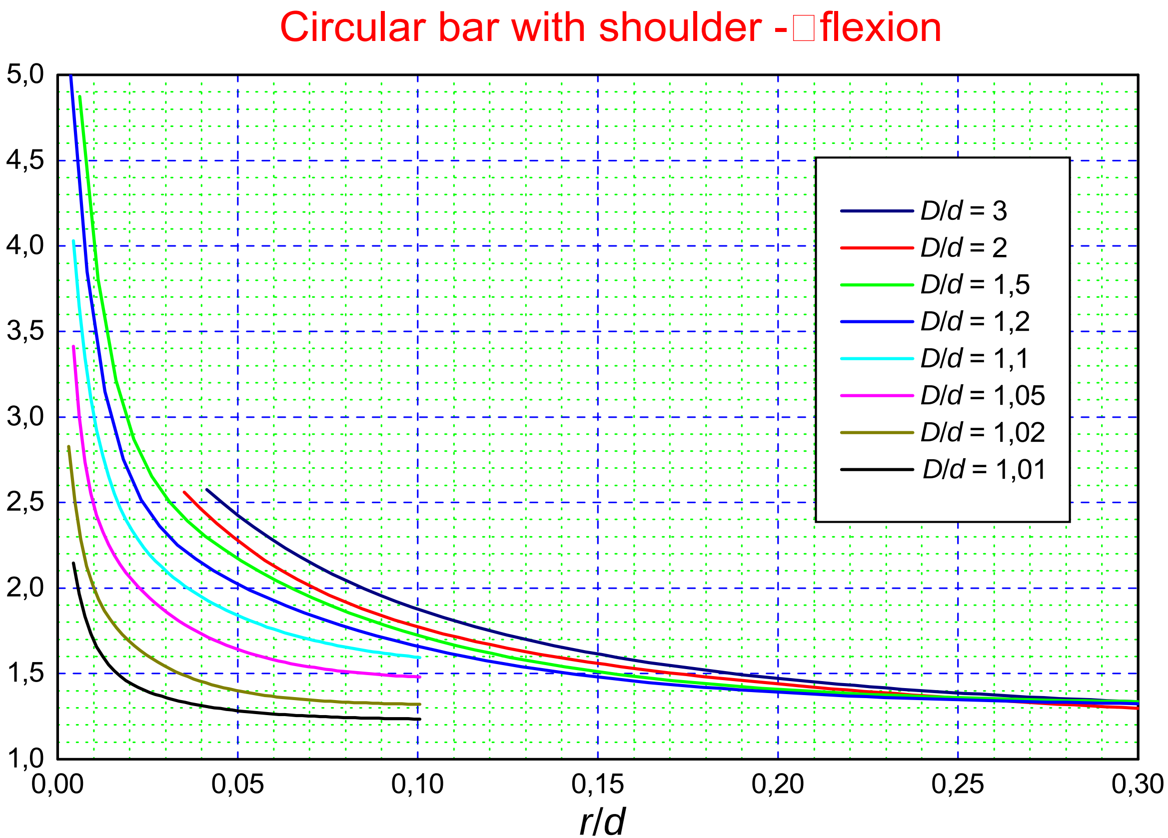


Overview of shapes

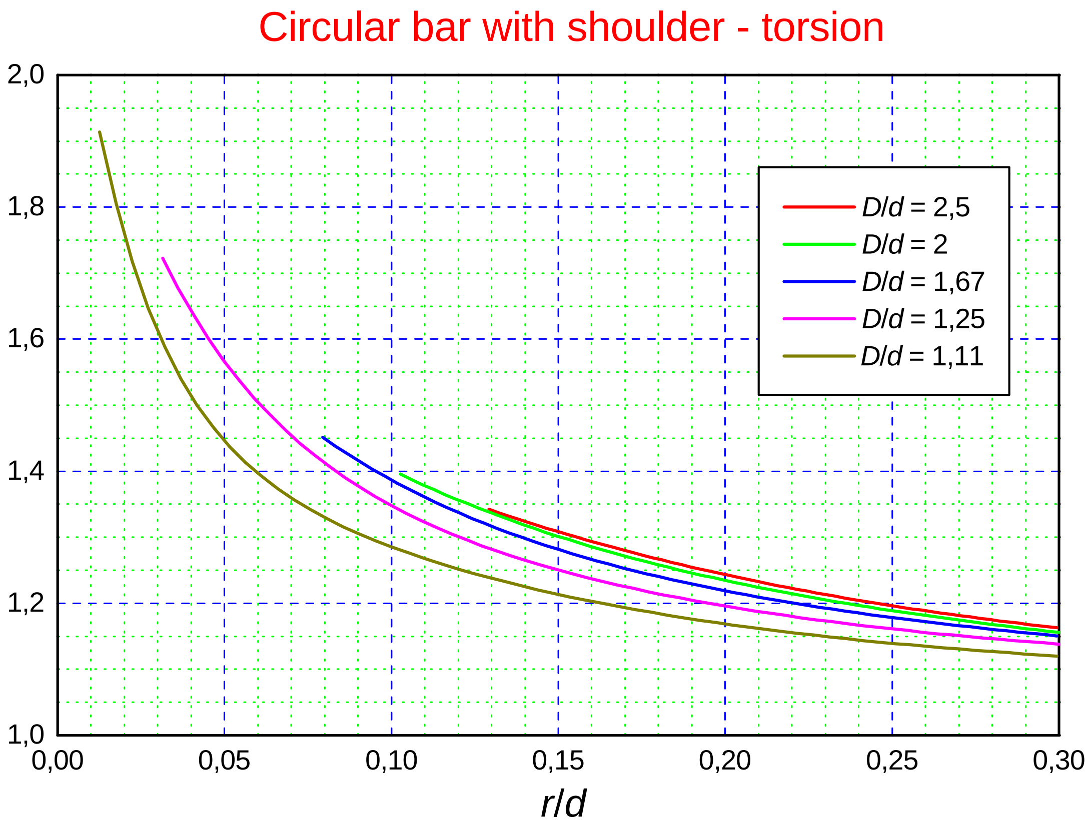
Circular bar with shoulder - tension



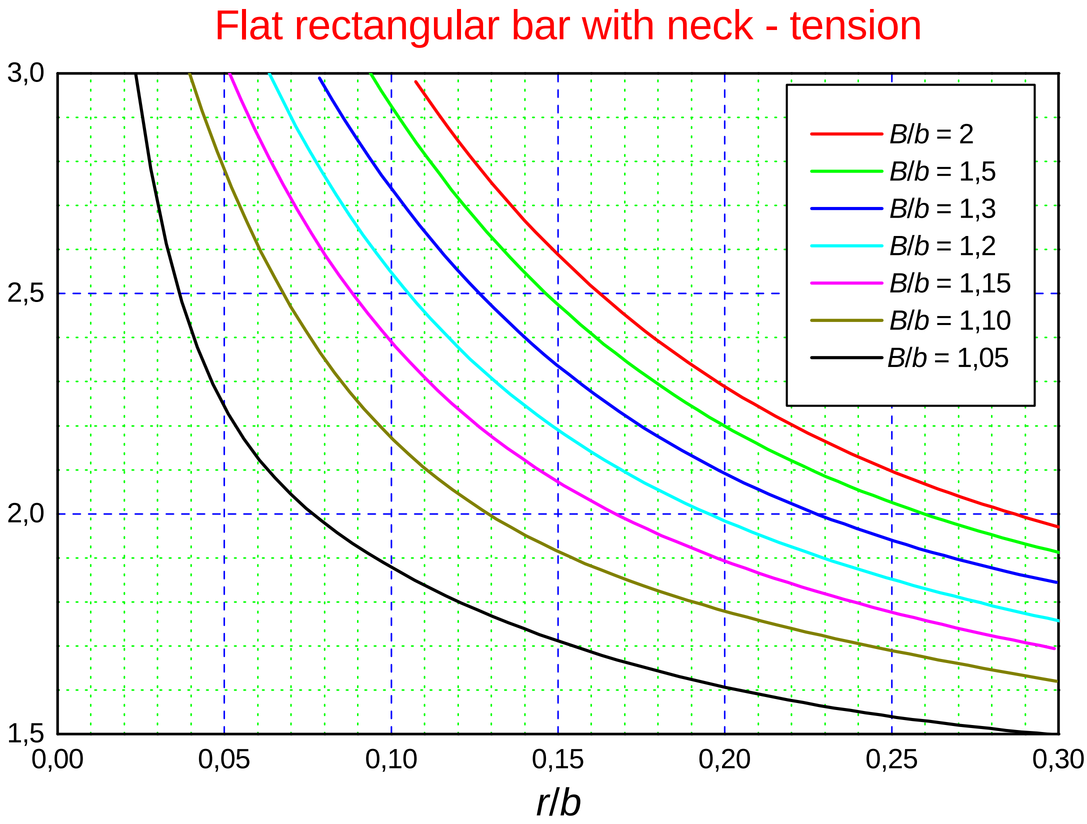
Overview of shapes



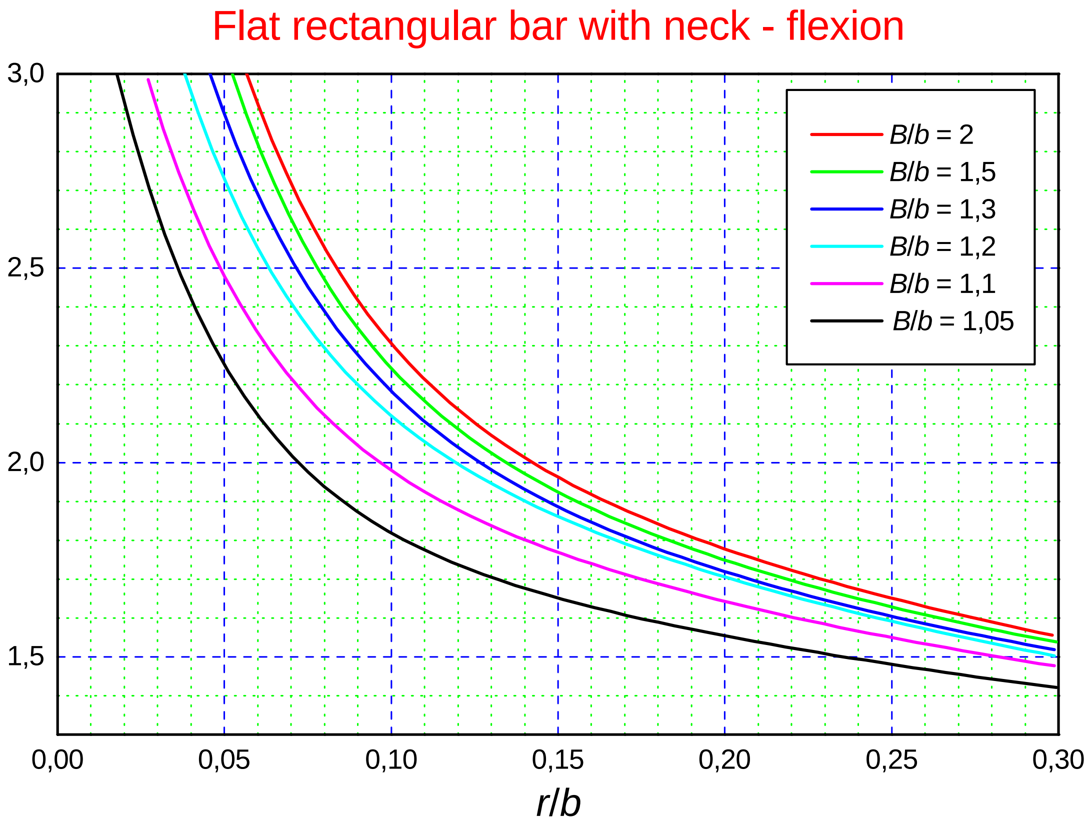
Overview of shapes



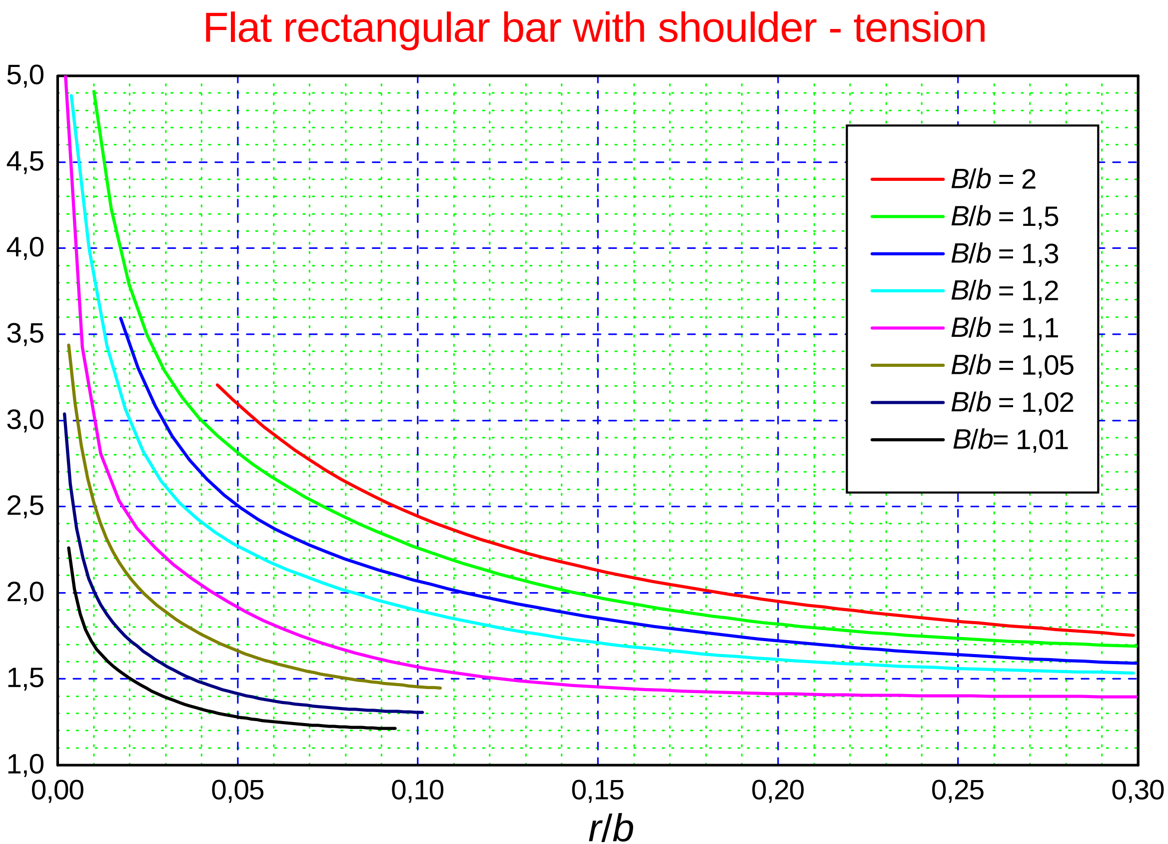
Overview of shapes



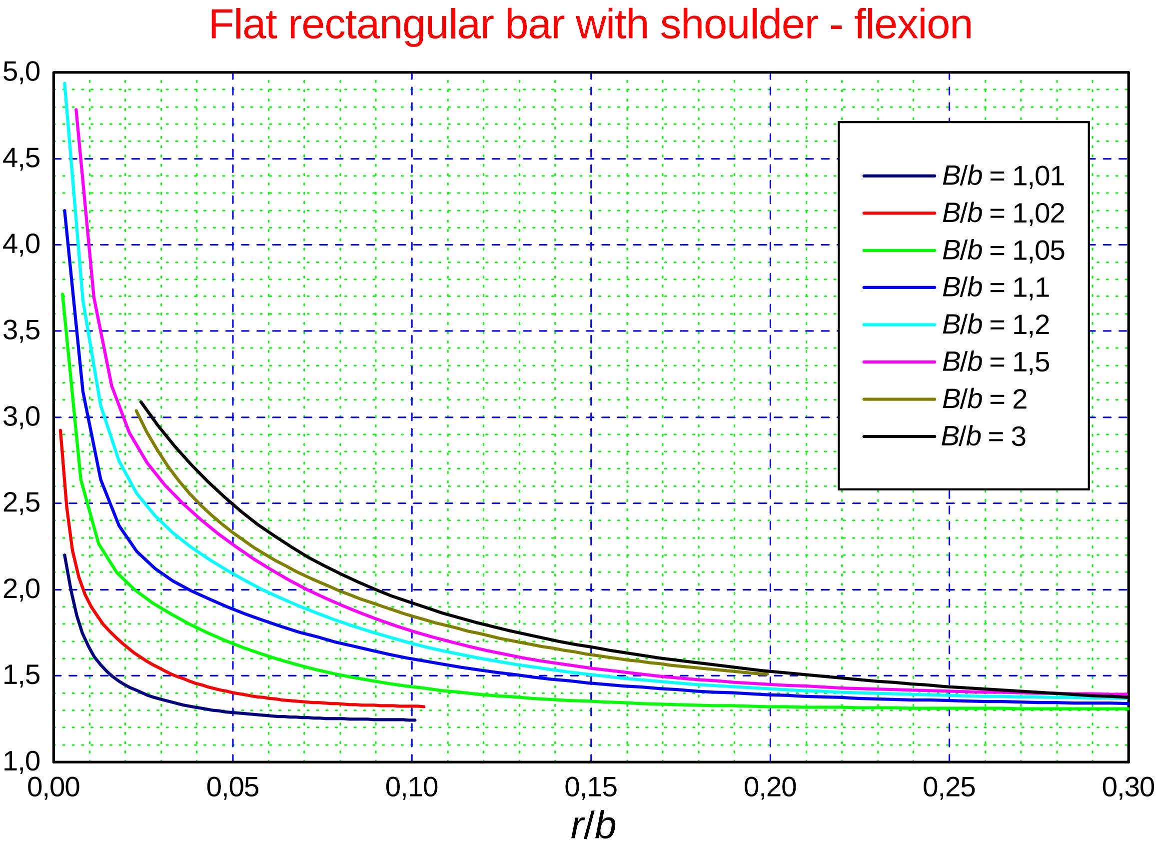
Overview of shapes



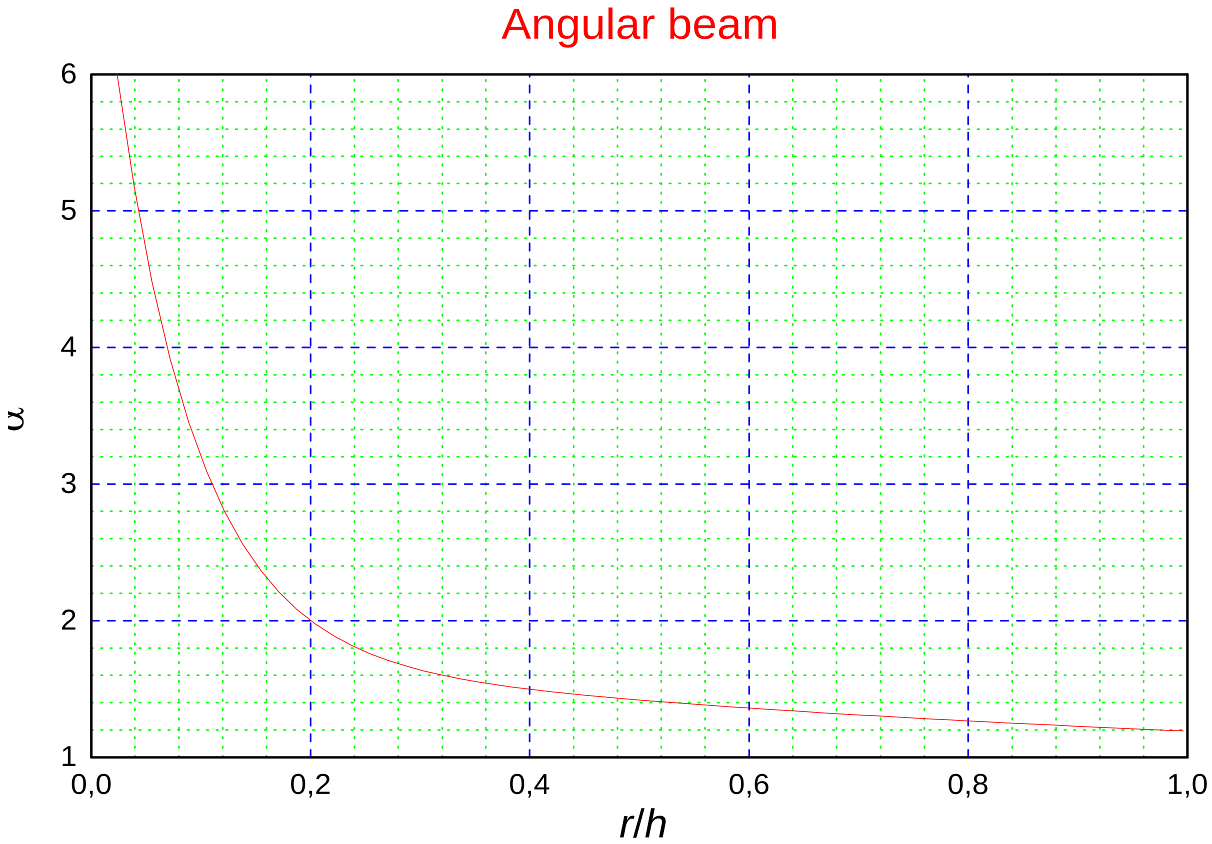
Overview of shapes



Overview of shapes



Overview of shapes



Overview of shapes