Buckling

The analysis and design of compression members can differ significantly from that of members loaded in tension or in torsion. If you were to take a long rod or pole, such as a meterstick, and apply gradually increasing compressive forces at each end, very small axial deflections would happen at first, but then the stick would bend (buckle), and very quickly bend so much as to possibly fracture. It is advisable to distinguish compression members according to their length and according to whether the loading is central or eccentric.

1. Long columns with central loading
2. Intermediate-length columns with central loading
3. Columns with eccentric loading
4. Struts or short columns with eccentric loading

The first two load types are valid for the ideal rod. The actual rod may have a center line with initial curvature due to production. And due to the assembly, the eccentrically acting load. It is often not possible to prevent such deviations (imperfections) even though these deviations are often very small, it is advisable to include them in the strength assessment using the third and fourth types.

Columns with eccentric loading:
The Secant equation for the stress calculation in the extreme fiber of a profile.

$$\frac{F_{max}}{S} = R_{p0,2T} \Big/ \left[1 + \frac{ec}{i^2} sec\left(\frac{L * \beta}{2i}\sqrt{\frac{F_{max}}{ES}}\right)\right]$$

applies under the following conditions:

$$\frac{L * \beta}{i} > 0{,}282\sqrt{\frac{ES}{F}}$$

$$\frac{F_{max}}{S_F} * C_c \geq F$$

F_{max}	maximal (critical) force	[N]
S	profile area	[mm^2]
$R_{p0,2T}$	the minimum yield strength or 0,2% proof strength at calculation temperature	[MPa]
e	eccentricity	[mm]
c	extreme fiber distance	[mm]
i	gyration radius	[mm]
L	strut length	[mm]
$ß$	type of strut mounting	[]
E	Young's modulus	[MPa]
F	axial force	[N]
S_F	safety factor	[]
C_c	coefficient according to load	[]

Struts or short columns with eccentric loading:

$$\frac{F_{max}}{S} = R_{p0,2T} / \left[1 + \frac{ec}{i^2}\right]$$

applies under the following conditions:

$$\frac{L * \beta}{i} \leq 0{,}282 \sqrt{\frac{ES}{F}}$$

$$\frac{F_{max}}{S_F} * C_c \geq F$$

F_{max}	maximal (critical) force	[N]
S	profile area	[mm^2]
$R_{p0,2T}$	the minimum yield strength or 0,2% proof strength at calculation temperature	[MPa]
e	eccentricity	[mm]
c	extreme fiber distance	[mm]
i	gyration radius	[mm]
L	strut length	[mm]
$ß$	type of strut mounting	[]
E	Young's modulus	[MPa]
F	axial force	[N]
S_F	safety factor	[]
C_c	coefficient according to load	[]

Type of strut mounting:

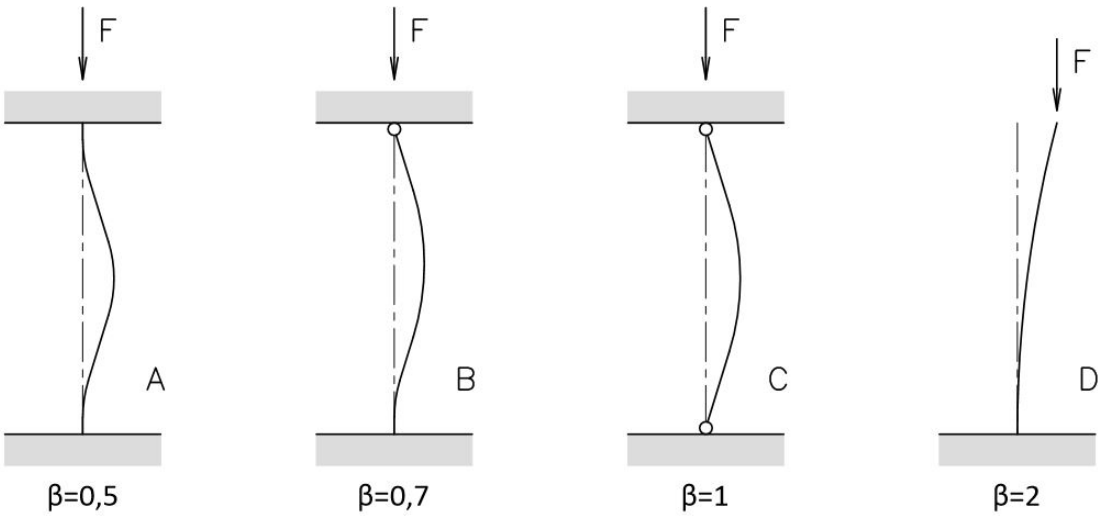

Fig. 1 type of strut mounting

Coefficient according to load:

load	[]
Static load	1
Unidirectional load, non-impact load	0,8
Unidirectional load, with a small impact load	0,7
Unidirectional load, with a big impact load	0,6
Alternating load, with a small impact load	0,45
Alternating load, with a big impact load	0,25

Literature:

Joseph E. Shigley, Charles R. Mischke, Richard G. Budynas: Konstruování strojních součástí 2010.