

Form factors for angle, T and channel sections under combined bending and axial load

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The preparation of this Data Item

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FORM FACTORS FOR ANGLE, T AND CHANNEL SECTIONS UNDER COMBINED BENDING AND AXIAL LOAD

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FORM FACTORS FOR ANGLE, T AND CHANNEL SECTIONS UNDER COMBINED BENDING AND AXIAL LOAD

1. NOTATION

b	total thickness of web or webs	in	m
d	width of flange	in	m
E	modulus of elasticity	lbf/in ²	N/m ²
f_n	stress at which tangent modulus $E_t = E/2$	lbf/in ²	N/m ²
f_p	0.2 per cent proof stress of material	lbf/in ²	N/m ²
h	depth of section	in	m
K	form factor defined by $\frac{\text{maximum plastic moment}}{\text{maximum elastic moment}}$		
M	bending moment in section	lbf in	N m
M_{max}	maximum permissible bending moment	lbf in	N m
m	Ramberg-Osgood material characteristic (see ESDU 76016)		
P	axial load applied through centroid of section in sense that increases stress due to bending at free edge of web or webs	lbf	N
t	thickness of flange	in	m
x	axis of asymmetry (about the bending axis), see Sketch 2.1		
y	distance of centroid of section from base (see Sketch 2.1)		
	$= \frac{h}{2} \frac{\left[1 + \left(\frac{d}{b} - 1 \right) \left(\frac{t}{h} \right)^2 \right]}{\left[1 + \left(\frac{d}{b} - 1 \right) \frac{t}{h} \right]}$	in	m
Z	maximum section modulus	in ³	m ³
	$= \frac{bh^2}{6} \left[\frac{1 + \left(\frac{d}{b} - 1 \right) \frac{t}{h} \left[4 - 6 \frac{t}{h} + 4 \left(\frac{t}{h} \right)^2 + \left(\frac{d}{b} - 1 \right) \left(\frac{t}{h} \right)^3 \right]}{1 + \left(\frac{d}{b} - 1 \right) \left(\frac{t}{h} \right)^2} \right]$		
σ	varying stress from 0.2 per cent proof stress to 0.5 per cent proof stress. (see Sketch 3.1)	lbf/in ²	N/m ²

Both British and SI units are quoted but any coherent system of units may be used.

2. INTRODUCTION

This Data Item presents form factor, K , curves to calculate the maximum permissible bending moments, M_{max} , for sections that are NOT symmetrical about the x -axis (see Sketch 2.1). For sections such as T- and channel-sections (see Sketch 2.1), the maximum permissible bending moment, M_{max} , is reduced by the application of axial load, P , when that load acts so as to cause failure of the outstanding leg. An estimate of the effect of an axial load, P , acting in this sense on the permissible bending moment, M_{max} , of T- and channel-sections may be made by use of the K curves (Figures 1 to 5) presented in this Data Item. The form factor K is plotted against Py/M for various values of b/d for six values of t/h . For convenience the form factor has been related to the 0.2 per cent proof stress of the material. Values of K taken from the curves give directly the values of the maximum permissible bending moment, M_{max} , appropriate to a given constant ratio of bending moment and axial load as represented by the ratio Py/M . For other cases a process of successive approximation is necessary. The values of K for $Py/M = 0$ correspond to pure bending.

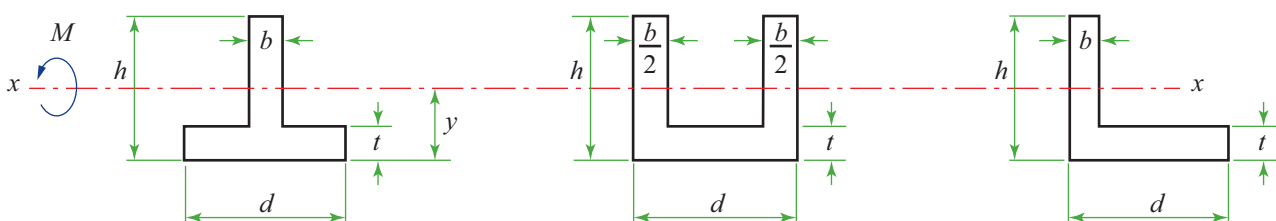
This Data Item supersedes Data Item ESDU Struct 01.06.03. The form factors provided in this Data Item incorporate the Ramberg-Osgood formula to define the stress-strain curve of the material which replaces the idealised stress-strain curve approach used in ESDU Struct 01.06.03. This Data Item also presents values of K for values of Py/M up to 20 in all of its figures.

No account has been taken of any type of instability, the possibility of which must also be considered (see, for example, Data Items Struct 01.01.08 and 01.01.09).

This Data Item applies strictly to the case when the end load acts in a direction such as to cause failure of the outstanding leg. If the end load acts in the opposite sense the form factor is slightly greater than the value given by this Data Item and, in that case, ESDU 90004 can be used to obtain more accurate results, P ; it should be noted that it is possible that failure of the flanges might be the critical case and not failure of the outstanding leg.

Sketch 2.2 supports the conclusion reached in Derivation 2 that K values are not very sensitive to the variation of the material characteristic m (gradually yielding to sharply yielding). K values are presented in Figures 1 to 5 in this Data Item for a material with a typical value of the material characteristic m . For a material with a specific value of the material characteristic m ESDU 90004 can be used to obtain more accurate results.

For L-sections and other sections that are NOT symmetric about the x -axis this Data Item applies only when they are constrained to bend about the x -axis shown in Sketch 2.1.



Sketch 2.1 Examples of sections that are NOT symmetrical about the x -axis that are covered by this Data Item
(see Figures 1 to 5)