

FORM FACTORS FOR ANGLE, TEE 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
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 $M_{max} = K f_p Z$		
M	bending moment in section	lbf in	N m
M_{max}	maximum permissible bending moment	lbf in	N m
P	load in section in sense that increases stress due to bending at free edge of web or webs	lbf	N
t	thickness of flange	in	m
y	distance of centroid of section from base	in	m
	$= \frac{h \left[1 + \left(\frac{d}{b} - 1 \right) \left(\frac{t}{h} \right)^2 \right]}{2 \left[1 + \left(\frac{d}{b} - 1 \right) \frac{t}{h} \right]}$		
Z	maximum section modulus	in ³	m ³
	$= \frac{bh^2}{6} \left[\frac{1 + \left(\frac{d}{b} - 1 \right) \frac{t}{h} \left[4 - 6 \frac{t}{h} + 4 \left(\frac{t}{h} \right)^2 + \left(\frac{d}{b} - 1 \right) \left(\frac{t}{h} \right)^3 \right]}{1 + \left(\frac{d}{b} - 1 \right) \left(\frac{t}{h} \right)^2} \right]$		

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

2. NOTES

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 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.

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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 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.

For L- and other anti-symmetrical sections this Data Item applies only when they are constrained to bend about the axis shown.

3. DERIVATION

1. BARRETT, A.J. Note on the bending of some common beam sections into the plastic range. *Jl R. Aeronaut. Soc.*, Vol. 57, No. 2, pp. 110-115, February 1953.
2. BARRETT, A.J. Unsymmetrical bending and bending combined with axial loading of a beam of rectangular cross section into the plastic range. *Jl R. Aeronaut. Soc.*, Vol. 57, No. 8, pp. 503-509, August 1953.

4. EXAMPLES

(1) Find the maximum bending moment and tensile end load when combined in the ratio $P_y/M = 1.0$ that a Tee-section beam may be expected to carry when $h = 2.0$ in, $b = 0.3$ in, $d = 1.5$ in, $t = 0.4$ in, and $f_p = 50\,000$ lbf/in².

Then

$$\frac{b}{d} = 0.2, \frac{t}{h} = 0.2 \text{ and } \left(\frac{d}{b} - 1\right) = 4.$$

Substituting in the expressions given in the notation gives

$$y = \frac{2.0(1 + 4 \times 0.2^2)}{2(1 + 4 \times 0.2)} = 0.644 \text{ in,}$$

and

$$\begin{aligned} Z &= \frac{0.3 \times 2.0^2}{6} \left[\frac{1 + 4 \times 0.2(4 - 6 \times 0.2 + 4 \times 0.2^2 + 4 \times 0.2^3)}{1 + 4 \times 0.2^2} \right] \\ &= 0.585 \text{ in}^3. \end{aligned}$$

From the curves,

$$K = 0.48.$$

Hence,

$$\begin{aligned} M_{max} &= 0.48 \times 0.585 \times 50\,000 \\ &= 14\,000 \text{ lbf in} \end{aligned}$$