

LOCAL INSTABILITY OF STRUTS WITH FLAT SIDES

1. NOTATION

d	width of side with one free edge	m	in
E	modulus of elasticity of material in compression	N/m ²	lbf/in ²
E_t	tangent modulus of elasticity of material in compression as stress f	N/m ²	lbf/in ²
f	average stress at which local instability occurs	N/m ²	lbf/in ²
f_n	stress at which $E_t = \frac{1}{2}E$ (see Item No. 76016)	N/m ²	lbf/in ²
h	width of side supported at both edges	m	in
K	buckling stress coefficient defined by $f = KE_t(t/h)^2$ or $f = KE_t(t/d)^2$		
m	material characteristic (see Item No. 76016)		
t	thickness of sides	m	in

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

2. NOTES

The stress ratio f/f_n is plotted against $(h/t)(f_n/KE)^{1/2}$ or $(d/t)(f_n/KE)^{1/2}$ for open or closed flat-sided sections for a range of values of m . The auxiliary right-hand scale marked $(f_n/E)^{1/2}$ and the straight lines marked d/t are added for convenience in computation and enable f/f_n to be read directly against h/t or d/t .

It is assumed that the length of the strut is at least four times h or d , whichever is the larger; h and d are measured as though the sections were sharp-cornered.

For an open section it is assumed that the lip provides sufficient support to prevent the webs buckling sideways; this will generally be so, provided that d is greater than $5t$. Minimum radii at the corners and a degree of initial straightness consistent with current practice have also been assumed.

The sides have been treated as plates simply-supported at their edges but in fact the sides that have higher buckling stresses will exert restraints on those with lower buckling stresses. Moreover, in general there will be interaction between different modes of instability, for example local and torsional, and these effects are fully accounted for in Item Nos 76023 and 77030. In the case of a panel with Z-section stringers Data Item No. 71014 gives the local buckling stress when account of the restraint given by the plate is included.

When the local instability mode is known to predominate, this Item gives, in most cases, a good estimate of the stress at which instability sets in. The onset of local instability will result in an appreciable loss of stiffness but not necessarily in complete failure, which will depend upon the loading conditions and the surrounding structure.

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For other types of local instability see Data Item No. 78021. Data Item No. 90002* provides a computer program that may be used to calculate f from the material properties and d or h and t directly.

3. DERIVATION

The curves are based on the following assumptions, which are derived from Data Item No. 72019 and experimental results.

For sides with both edge supported $f_{xe}/f_0 = 1.0$.

For sides with one free edge $f_{xe}/f_0 = 0.16$.

E_t is obtained from the expression

$$E_t = \frac{E}{1 + (f/f_n)^{m-1}}.$$

4. EXAMPLE

To find the average stress at which local instability occurs in a strut of Z-section, when

$$t = 0.048 \text{ in}, h = 1.50 \text{ in}, d = 0.75 \text{ in}$$

and the properties of the material are

$$E = 10 \times 10^6 \text{ lbf/in}^2,$$

$$0.1 \text{ per cent proof stress} = 52\,000 \text{ lbf/in}^2$$

$$\text{and } 0.2 \text{ per cent proof stress} = 55\,000 \text{ lbf/in}^2.$$

From Data Item No. 76016, and in the notation of that Item, Figure 5 gives the material characteristic, m , as 12.5 for the given values ϵ_R , ϵ_R' , f_R and f_R' . Hence

$$\frac{m\epsilon_R E}{f_R} = \frac{12.5 \times 0.002 \times 10 \times 10^6}{55\,000} = 4.55$$

and, from Figure 6,

$$f_n/f_R = 0.875.$$

Therefore

$$f_n = 0.875 \times 55\,000 = 48\,100 \text{ lbf/in}^2$$

and

$$(f_n/E)^{1/2} = 0.0693.$$

Also

$$h/t = 31.2 \text{ and } d/t = 15.6.$$

From the Figure 1, starting at the right-hand scale at $(f_n/E)^{1/2} = 0.0693$ and, following the arrowed lines, interpolation yields,

$$\text{for } h/t = 31.2 \quad f/f_n = 0.735$$

$$\text{and for } d/t = 15.6 \quad f/f_n = 0.51.$$

* Data Item No. 90002 "Struts: strength under flexural, local and inter-rivet buckling."